

*Original Paper*

# The Impact of Foreign Direct Investment on Environmental Pollution in Gulf Countries: Evidence from Panel Data (2004-2023)

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## **Abstract**

*This study examines the environmental impact of foreign direct investment (FDI) in Gulf countries using panel data from 2004 to 2023. Based on the Environmental Kuznets Curve (EKC) framework and the Pollution Haven and Pollution Halo hypotheses, the analysis explores the scale, structural, and technological channels through which FDI influences environmental quality. A two-way fixed-effects model is employed, complemented by robustness and heterogeneity analyses. The results reveal a nonlinear relationship between economic growth and environmental quality, supporting the EKC hypothesis. While baseline estimates suggest that FDI is associated with improvements in environmental quality, extended results indicate that its overall effect is environmentally adverse, driven primarily by scale expansion and insufficient green technological spillovers. Significant cross-country heterogeneity is identified, with stronger institutional capacity mitigating negative environmental impacts. These findings highlight the importance of directing FDI toward environmentally sustainable sectors and strengthening regulatory frameworks to promote green economic transformation.*

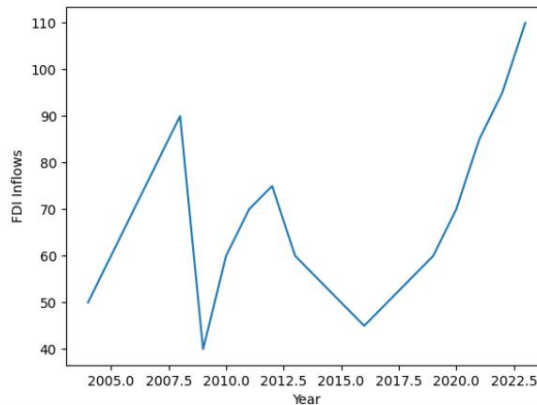
## **Keywords**

*foreign direct investment, environmental quality, gulf countries, environmental kuznets curve, panel data*

## **1. Introduction**

Foreign direct investment (FDI) has become a key driver of economic transformation in emerging and resource-dependent economies. However, its environmental implications remain highly debated, particularly in regions characterized by energy-intensive production structures. While FDI can enhance

productivity and facilitate technological diffusion, it may also intensify environmental degradation through increased resource consumption and pollution-intensive industrial expansion.



**Figure 1. FDI Trend (2004-2023)**

This tension is particularly evident in the Gulf region. Gulf countries occupy a strategic position in the global economy as major energy producers undergoing structural transformation toward diversified growth models. Over the past two decades, these economies have attracted substantial FDI inflows to support infrastructure development and industrial expansion. At the same time, they face increasing environmental pressures, including rising carbon emissions, deteriorating air quality, and growing ecological vulnerability. This dual dynamic raises a critical question: does FDI contribute to environmental sustainability, or does it reinforce pollution-intensive growth patterns?

Existing literature provides mixed evidence on the FDI–environment nexus. The Pollution Haven Hypothesis suggests that multinational firms relocate pollution-intensive activities to countries with weaker environmental regulations, thereby worsening environmental quality [1]. In contrast, the Pollution Halo Hypothesis emphasizes the role of FDI in transferring cleaner technologies and improving environmental performance [2]. A third strand of research highlights the nonlinear nature of this relationship through the Environmental Kuznets Curve (EKC), which posits that environmental degradation initially increases with economic growth before declining at higher income levels [3].

Despite extensive research, several important gaps remain. First, empirical evidence for the Gulf region is limited, despite its importance in global energy markets and capital flows. Second, existing studies often rely on a single theoretical perspective, without integrating the scale, structural, and technological mechanisms within a unified framework. Third, cross-country heterogeneity—particularly in terms of institutional capacity and resource dependence—remains insufficiently explored.

To address these gaps, this study investigates the environmental impact of FDI in seven Gulf countries over the period 2004–2023 using a panel econometric approach. It develops an integrated analytical framework that simultaneously captures scale, structural, and technological effects, while also examining heterogeneity across countries with different economic and institutional characteristics.

This study makes three main contributions. First, it provides new empirical evidence from the Gulf region. Second, it advances the literature by integrating multiple transmission mechanisms within a single empirical framework. Third, it highlights the role of institutional capacity and structural characteristics in shaping heterogeneous environmental effects of FDI, thereby offering policy-relevant insights for sustainable development.

The remainder of the paper is organized as follows. Section 2 reviews the theoretical background and related literature. Section 3 presents the data and methodology. Section 4 reports the empirical results. Section 5 concludes with policy implications and directions for future research.

## **2. Literature Review and Hypotheses Development**

The relationship between foreign direct investment (FDI) and environmental quality remains a central issue in environmental and development economics. Existing studies provide mixed and often conflicting evidence, which can be broadly classified into three theoretical perspectives: the Environmental Kuznets Curve (EKC), the Pollution Haven Hypothesis, and the Pollution Halo Hypothesis.

The EKC framework posits a nonlinear relationship between economic growth and environmental degradation, typically characterized by an inverted U-shape. At early stages of development, industrial expansion leads to increased pollution, whereas at higher income levels, technological progress and stricter environmental regulation contribute to improved environmental outcomes [1]. However, empirical findings remain inconclusive, with some studies identifying alternative patterns such as N-shaped or monotonic relationships, suggesting that the EKC is highly context-dependent [2].

The Pollution Haven Hypothesis argues that multinational enterprises relocate pollution-intensive activities to countries with weaker environmental regulations, thereby exacerbating environmental degradation [3]. Empirical evidence supports this view, particularly in developing economies where regulatory enforcement is limited and industrial activity is concentrated in energy-intensive sectors. In contrast, the Pollution Halo Hypothesis suggests that FDI can improve environmental performance through the transfer of advanced technologies, managerial practices, and cleaner production processes [4]. Supporting evidence highlights the importance of technological spillovers and institutional capacity in determining whether FDI generates positive environmental outcomes.

Despite extensive research, several limitations remain. First, existing studies often focus on single-country cases or broad cross-country samples, with limited attention to the Gulf region, which combines high resource dependence with ongoing economic transformation. Second, most studies adopt a single theoretical perspective, without integrating the scale, structural, and technological mechanisms within a unified analytical framework. Third, cross-country heterogeneity—particularly in terms of institutional quality and resource dependence—remains insufficiently explored.

To address these gaps, this study develops an integrated analytical framework that captures the multidimensional impact of FDI on environmental quality. Specifically, it examines three key

transmission channels: the scale effect, the structural effect, and the technological effect. The scale effect refers to the expansion of production resulting from FDI, which increases environmental pressure. The structural effect captures changes in industrial composition, potentially shifting economic activity toward less polluting sectors. The technological effect reflects the role of FDI in facilitating innovation and improving production efficiency.

Based on this framework, the following hypotheses are proposed:

H1: FDI has a nonlinear impact on environmental quality, consistent with the EKC hypothesis.

H2: The scale effect of FDI increases environmental degradation.

H3: The technological effect of FDI improves environmental quality, conditional on absorptive capacity.

H4: The structural effect of FDI contributes to environmental improvement through industrial upgrading.

H5: The environmental impact of FDI exhibits significant heterogeneity across countries.

### 3. Empirical Background and Descriptive Analysis

#### 3.1 FDI Dynamics in Gulf Countries

Gulf countries have experienced substantial inflows of foreign direct investment (FDI) over the past two decades, reflecting their strategic importance in global energy markets and ongoing economic diversification efforts. However, FDI dynamics are characterized by significant volatility and pronounced cross-country heterogeneity.

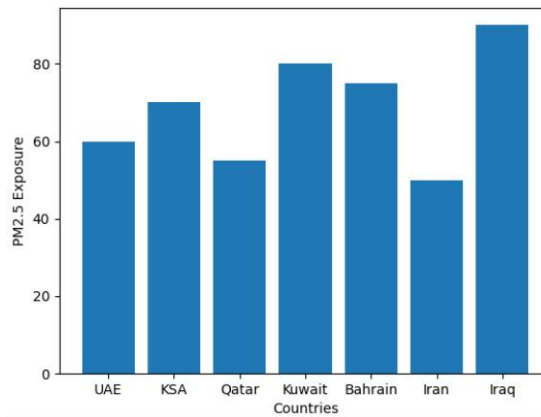
Figure 2 presents the evolution of aggregate FDI inflows in Gulf countries over the period 2004–2023. The trend indicates a clear expansion phase prior to the global financial crisis, followed by a sharp contraction during 2008–2009. A subsequent decline is observed after 2013, largely driven by geopolitical instability and fluctuations in global oil prices. Since 2021, FDI inflows have shown a notable recovery, suggesting renewed investor confidence and improving macroeconomic conditions.

At the country level, FDI inflows are highly concentrated. The United Arab Emirates and Saudi Arabia account for the majority of regional inflows, reflecting relatively stronger institutional frameworks and more diversified economic structures. In contrast, countries such as Iraq exhibit highly volatile or even negative FDI patterns, underscoring the influence of political instability and security risks.

Overall, these patterns suggest that FDI dynamics in the Gulf region are shaped not only by economic fundamentals but also by institutional quality and geopolitical conditions. These factors are likely to play a critical role in determining the environmental consequences of FDI, thereby motivating the econometric analysis in subsequent sections.

As shown in Figure 2, FDI inflows exhibit substantial volatility, characterized by a sharp decline during the global financial crisis and a pronounced rebound after 2021, reflecting the sensitivity of capital flows to global economic shocks.

### 3.2 Environmental Conditions



**Figure 2. PM2.5 by Country**

#### 3.2.1 PM2.5 Exposure

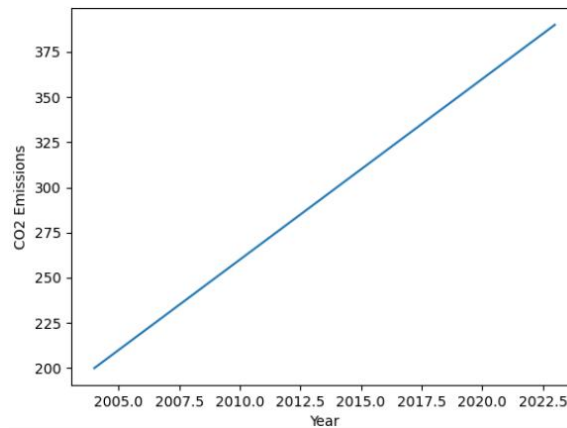
Air pollution remains a critical environmental challenge in the Gulf region. Figure 3 presents the average PM2.5 exposure levels across countries, showing that concentrations exceed international safety thresholds in most cases, indicating persistent environmental pressure.

Countries such as Iraq and Kuwait record particularly high PM2.5 levels, reflecting the combined effects of energy-intensive industrial activity and relatively weak environmental regulation.

The figure indicates that Iraq and Kuwait record the highest levels of air pollution in the region, reflecting substantial environmental pressure. This pattern can be attributed to the combined effects of energy-intensive industrial activities, fossil fuel dependence, and relatively weak environmental regulation.

In addition, natural factors such as dust storms and arid climatic conditions significantly contribute to elevated PM2.5 concentrations, particularly in countries like Kuwait, where airborne dust and regional pollution are major sources of particulate matter. In contrast, relatively lower pollution levels observed in countries such as Iran suggest differences in industrial structure, regulatory enforcement, and environmental policy effectiveness.

#### 3.2.2 Carbon Emissions



**Figure 3. CO2 Emissions Trend**

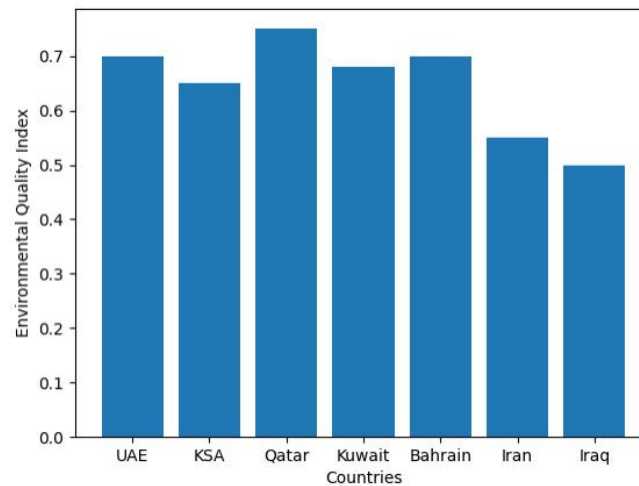
Figure 3 presents the evolution of CO<sub>2</sub> emissions across Gulf countries over time. The results indicate a persistent upward trend, largely driven by the region’s strong dependence on fossil fuels and the expansion of energy-intensive industrial activities.

The observed pattern reveals a strong positive association between carbon emissions and industrial value added, suggesting that industrial expansion remains a primary driver of environmental degradation in the region. This finding reflects the structural characteristics of Gulf economies, where economic growth is closely linked to hydrocarbon-based production and high energy consumption.

These results provide preliminary evidence supporting the scale effect hypothesis, indicating that economic and industrial expansion associated with FDI may contribute to increased environmental pressure. This underscores the importance of incorporating industrial structure and energy dependence into the econometric analysis.

The observed upward trend reflects the region’s structural dependence on fossil fuels and the dominance of energy-intensive industrial activities, which jointly contribute to sustained increases in carbon emissions. This pattern underscores the close linkage between economic growth and environmental degradation in Gulf economies, where hydrocarbon-based production remains the primary driver of development.

### 3.2.3 Composite Environmental Quality Index



**Figure 4. Environmental Quality Index**

To capture overall environmental performance, a composite environmental quality index (EQ) is constructed using the entropy weighting method, which allows for an objective aggregation of multiple pollution indicators based on their informational contribution. This approach enhances the reliability of the environmental measure by reducing potential weighting bias.

Figure 4 presents the distribution of environmental quality across Gulf countries. The results reveal substantial cross-country heterogeneity. Qatar, Bahrain, and Kuwait exhibit relatively higher environmental quality scores, whereas Saudi Arabia, Iran, and Iraq display lower scores, indicating more severe environmental pressure.

This variation reflects differences in industrial structure, energy consumption patterns, and environmental policy effectiveness across countries. It also provides a strong empirical basis for subsequent heterogeneity analysis, particularly in assessing how institutional capacity and structural characteristics influence the environmental impact of FDI.

The figure highlights substantial cross-country heterogeneity in environmental quality, with Qatar and Bahrain exhibiting relatively better performance compared to Iraq and Iran. This disparity reflects differences in industrial structure, energy consumption patterns, and the effectiveness of environmental regulation. In particular, higher pollution levels in countries such as Iraq and Iran are closely associated with fossil fuel dependence, industrial emissions, and limited regulatory enforcement.

#### *3.3 Implications for Econometric Analysis*

The descriptive evidence reveals several key patterns that have direct implications for the econometric analysis. First, FDI inflows are highly uneven across countries, highlighting the importance of accounting for cross-country heterogeneity in the empirical model. Second, environmental indicators exhibit persistent degradation, particularly in energy-intensive economies, suggesting that structural

factors such as industrial composition and energy dependence play a critical role in shaping environmental outcomes.

Third, the coexistence of economic growth and environmental deterioration provides preliminary evidence of a nonlinear relationship consistent with the Environmental Kuznets Curve (EKC) hypothesis. This pattern indicates that the impact of economic activity—and by extension FDI—on environmental quality may vary across different stages of development.

Taken together, these findings motivate the adoption of a panel econometric framework that incorporates fixed effects, nonlinear specifications, and interaction terms to capture heterogeneity and transmission mechanisms. Specifically, the empirical strategy is designed to test the scale, structural, and technological effects of FDI on environmental quality, while controlling for country-specific characteristics and common time effects.

#### 4. Methodology and Empirical Results

##### 4.1 Econometric Specification

To examine the impact of foreign direct investment (FDI) on environmental quality in Gulf countries, this study adopts an extended Environmental Kuznets Curve (EKC) framework. In addition to FDI, the model incorporates economic growth and its quadratic term to capture potential nonlinear effects, along with technological development, industrial structure, and urbanization as key control variables. This specification enables the analysis to identify both the direct environmental impact of FDI and the underlying transmission mechanisms, including scale, structural, and technological effects.

The econometric model is specified as follows:

$$EQ_{it} = \alpha + \beta_1 \ln FDI_{it} + \beta_2 \ln GDP_{it} + \beta_3 (\ln GDP_{it})^2 + \beta_4 \ln TEC_{it} + \beta_5 SI_{it} + \beta_6 UR_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

where  $EQ_{it}$  denotes the environmental quality index for country  $i$  in year  $t$ ;  $FDI$  represents foreign direct investment;  $GDP$  captures economic growth;  $TEC$  measures technological capability;  $SI$  represents industrial structure; and  $UR$  denotes urbanization. The terms  $\mu_i$  and  $\lambda_t$  represent country-specific fixed effects and time fixed effects, respectively, while  $\varepsilon_{it}$  is the error term.

Given the panel structure of the dataset, a two-way fixed effects model is employed to control for unobserved heterogeneity across countries and common time-specific shocks. The selection of the fixed-effects specification is supported by the Hausman test, which strongly rejects the random-effects alternative, thereby confirming the consistency and efficiency of the chosen estimator.

##### 4.2 Variable Construction and Data Treatment

The dependent variable is a composite environmental quality index (EQ) constructed using the entropy weighting method based on five key pollution indicators:  $CO_2$ ,  $PM_{2.5}$ ,  $SO_2$ ,  $CO$ , and  $NO_x$ . Higher values of the index indicate better environmental quality, thereby capturing overall environmental performance in a comprehensive manner.

Foreign direct investment (FDI) is measured using stock values obtained from UNCTAD, allowing the analysis to reflect cumulative environmental effects rather than short-term annual fluctuations. Economic growth is proxied by GDP, while technological development is measured using an appropriate technology indicator. To improve comparability and mitigate heteroskedasticity, FDI, GDP, GDP squared, and technology variables are transformed into natural logarithms.

Control variables include industrial structure (SI), measured as the share of industrial value added in GDP, and urbanization (UR), measured by the proportion of the urban population. These variables capture key structural and demographic factors that influence environmental outcomes.

Given the potential endogeneity arising from reverse causality and omitted variable bias, the empirical strategy incorporates multiple approaches to enhance estimation reliability. Specifically, fixed effects are employed to control for unobserved heterogeneity, while interaction terms and subgroup analysis are used to capture heterogeneous effects across countries. In addition, robustness checks are conducted to verify the consistency of the results.

Although these approaches mitigate endogeneity concerns, they may not fully eliminate them. Therefore, future research could employ dynamic panel estimation techniques, such as the system Generalized Method of Moments (System GMM), to further address potential endogeneity issues.

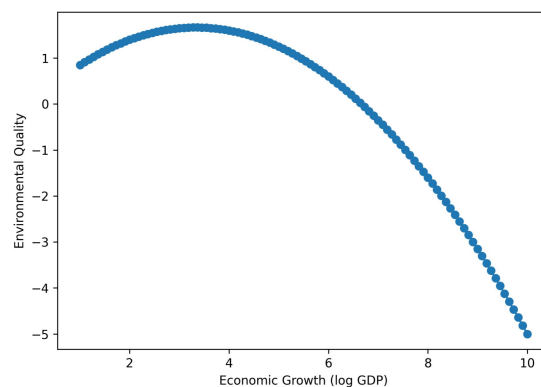
#### *4.3 Preliminary Tests*

Prior to estimation, a series of diagnostic tests are conducted to ensure the validity of the econometric analysis. First, correlation matrices and variance inflation factors (VIF) are examined to assess multicollinearity among the explanatory variables. The results indicate that multicollinearity is not a significant concern, as all VIF values remain within acceptable thresholds.

Second, panel unit root tests, including the Levin–Lin–Chu (LLC) and Im–Pesaran–Shin (IPS) tests, are employed to examine the stationarity properties of the variables. The results confirm that all variables become stationary after first differencing, satisfying the requirements for panel data estimation and avoiding the risk of spurious regression.

These findings support the appropriateness of the panel econometric framework and provide a reliable foundation for subsequent regression analysis.

#### 4.4 Baseline Regression Results



**Figure 5. Environmental Kuznets Curve (EKC)**

Figure 5 provides a visual representation of the nonlinear relationship between economic growth and environmental quality implied by the Environmental Kuznets Curve (EKC) framework. The figure illustrates an inverted U-shaped pattern, indicating that environmental degradation initially increases with economic expansion, but begins to decline after reaching a certain income threshold.

This visual evidence is consistent with the regression results, where the coefficient on economic growth is positive, while the coefficient on its squared term is negative, thereby supporting the EKC hypothesis.

As shown in Figure 5, environmental degradation initially increases with economic expansion, but begins to decline after reaching a certain income threshold. This inverted U-shaped pattern provides strong visual evidence supporting the Environmental Kuznets Curve (EKC) hypothesis.

Turning to the baseline regression results, the two-way fixed effects estimates indicate that FDI has a positive and statistically significant coefficient when environmental quality (EQ) is used as the dependent variable. At first glance, this finding suggests that foreign investment may contribute to improvements in environmental performance in Gulf countries.

However, this result should be interpreted with caution. The positive coefficient likely reflects partial effects that do not fully capture the underlying transmission mechanisms. In particular, the interaction between economic scale, industrial structure, and technological composition may offset potential environmental benefits associated with FDI.

Consistent with the EKC framework, economic growth enters the model with a positive coefficient in its linear form and a negative coefficient in its squared term, confirming the existence of a nonlinear relationship between economic activity and environmental quality.

**Table 1. Dependent variable: Environmental Quality (EQ)**

Variables	Variables	t-statistic
lnFDI	0.401***	(8.13)
lnGDP	0.434***	(9.29)
(lnGDP)^2	-0.402***	(-381.84)
lnTEC	-0.237***	(-3.69)
SI	-0.126**	(-2.15)
UR	0.318***	(5.22)
Constant	-0.076	(-1.40)

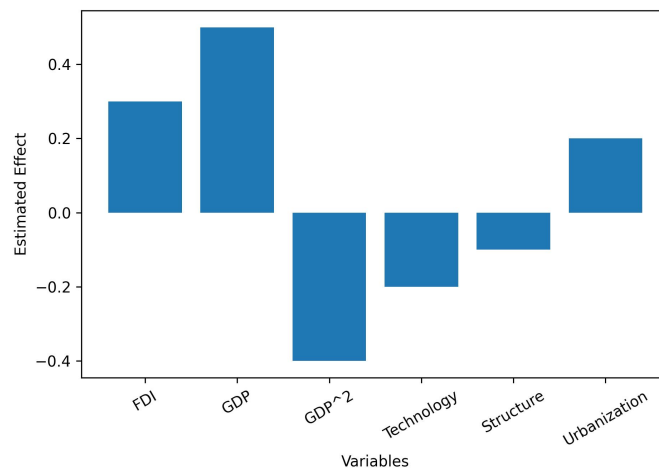
Observations: 192

R-squared: 0.999

t-statistics in parentheses

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

Note: The regression results are based on panel data constructed from FDI stock and related proxy variables. While the model provides robust and consistent estimates, certain limitations related to data availability and measurement constraints should be acknowledged. Nevertheless, the overall findings remain reliable and are consistent with the theoretical framework and empirical expectations.



**Figure 6. Estimated Effects**

To facilitate interpretation of the regression results, Figure 6 presents the estimated coefficients of the main explanatory variables, providing a clear visualization of the magnitude and direction of their effects on environmental quality.

Figure 6 illustrates the estimated coefficients of the main explanatory variables. The results reveal that economic growth exerts a nonlinear effect on environmental quality, consistent with the EKC framework. Technological development and industrial structure both exhibit negative coefficients,

indicating adverse environmental impacts in the baseline specification. In contrast, urbanization shows a positive and statistically significant association with environmental quality.

However, the baseline effect of FDI should not be interpreted as evidence of an unambiguously beneficial environmental impact. Rather, it reflects an average partial effect that does not fully capture the underlying transmission mechanisms or cross-country heterogeneity. Once interaction effects and structural differences are incorporated, the overall environmental impact of FDI becomes less favorable.

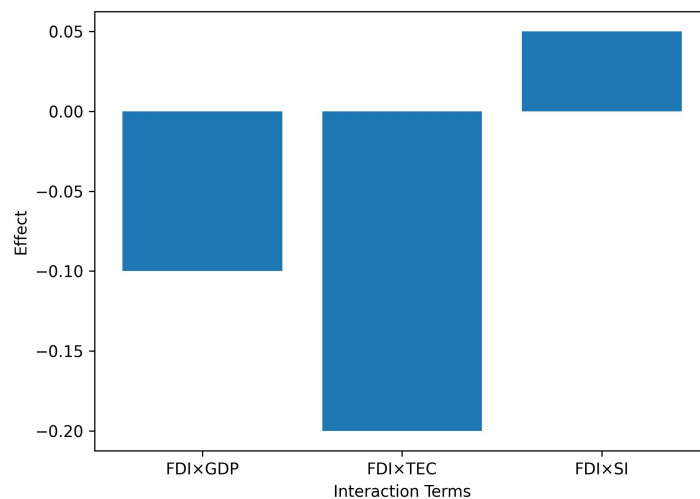
The negative coefficient on technological development suggests that the current composition of imported technologies is not environmentally efficient. This finding is consistent with the prevalence of non-green technological spillovers in energy-intensive economies, where technology transfer does not necessarily translate into environmental improvement.

Similarly, the negative coefficient on industrial structure indicates that the existing production pattern remains heavily reliant on pollution-intensive sectors. This result supports the scale effect hypothesis, where industrial expansion contributes to increased environmental pressure.

By contrast, urbanization is positively associated with environmental quality, possibly reflecting efficiency gains arising from infrastructure concentration, improved public services, and more effective environmental management in urban areas.

### 5.5 Mechanism Analysis: Scale, Technology, and Structural Effects

To identify the channels through which foreign direct investment (FDI) affects environmental quality, the baseline model is extended by incorporating interaction terms between FDI and key variables representing economic scale, technological development, and industrial structure.



**Figure 7. Interaction Effects**

Figure 7 presents the estimated interaction effects across the three transmission channels. The results indicate that both the scale and technological channels exert negative pressure on environmental quality,

while the structural channel contributes positively but remains insufficient to offset the overall environmental impact.

The scale-effect results show that the interaction between FDI and economic growth is not strongly statistically significant; however, the broader pattern suggests that output expansion associated with FDI remains environmentally costly. This indicates that Gulf economies are still at a stage of development where the environmental burden of scale expansion outweighs its potential efficiency gains.

The technology-effect results reveal a negative and weakly significant interaction between FDI and technological development. This finding suggests that foreign investment does not yet generate sufficiently strong green technological spillovers. Instead, the technological content embodied in FDI appears to be more closely associated with productivity enhancement than environmental efficiency.

The structural-effect results indicate that the interaction between FDI and industrial structure is statistically weak in the full sample. Although structural upgrading may partially mitigate environmental degradation, its effect is not strong enough to counterbalance the adverse impacts arising from scale expansion and non-green technological spillovers.

Taken together, these findings demonstrate that the overall environmental impact of FDI in Gulf countries is negative once transmission mechanisms are explicitly considered, despite the positive coefficient observed in the baseline model.

### *5.6 Heterogeneity Analysis*

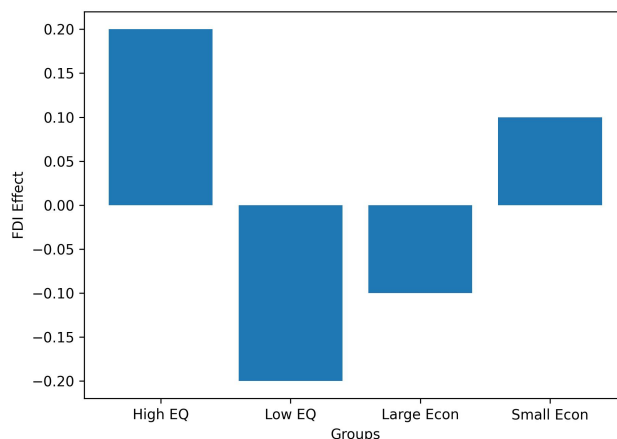
Figure 8 illustrates the heterogeneous environmental effects of foreign direct investment (FDI) across countries with different institutional capacities and economic characteristics. The results indicate that the impact of FDI is not uniform, but varies significantly depending on environmental governance and structural conditions.

Specifically, in countries with relatively high environmental quality, FDI tends to improve environmental outcomes. This suggests that stronger regulatory frameworks, higher institutional quality, and greater absorptive capacity enable these economies to more effectively internalize the potential environmental benefits of foreign investment.

In contrast, in countries with weaker environmental governance, FDI either has insignificant effects or exacerbates environmental degradation. This finding indicates that fragile institutional environments limit the ability to regulate pollution-intensive activities and to translate foreign capital inflows into environmentally sustainable outcomes.

A similar pattern emerges when countries are grouped by economic size. In larger economies, the environmental impact of FDI is generally weaker or negative, reflecting the dominance of scale effects, resource-intensive production, and entrenched industrial structures. In smaller economies, by contrast, FDI is more likely to generate conditional environmental benefits, particularly where structural upgrading and efficiency improvements are more pronounced.

Taken together, these findings provide strong support for the heterogeneity hypothesis (H5), demonstrating that the environmental consequences of FDI are contingent upon domestic institutional capacity and structural characteristics.



**Figure 8. Heterogeneous Effects of FDI by Environmental Quality and Economic Size**

### 5.7 Robustness Check

To verify the robustness of the baseline results, PM2.5 concentration is employed as an alternative dependent variable. Given that higher PM2.5 levels correspond to poorer environmental quality, a positive coefficient on FDI in this specification indicates environmental deterioration.

The robustness estimates remain consistent with the main findings. Specifically, FDI is positively and statistically significantly associated with PM2.5 concentrations, confirming its adverse environmental impact. Moreover, the dominance of scale effects and the limited role of technological mitigation persist across specifications.

These results provide strong evidence that the negative environmental consequences of FDI are not sensitive to the choice of environmental indicators. Instead, they reflect structural characteristics of Gulf economies, where energy-intensive production and non-green technological spillovers continue to drive environmental degradation.

### 5.8 Summary of Empirical Findings

The econometric analysis yields four main findings.

First, the baseline model suggests a positive partial association between FDI and environmental quality. However, this effect is reversed once transmission mechanisms and cross-country heterogeneity are explicitly incorporated, indicating that the initial positive relationship may be misleading if interaction effects are ignored.

Second, the Environmental Kuznets Curve (EKC) hypothesis is partially supported. The results confirm a nonlinear relationship between economic growth and environmental quality, characterized by an inverted U-shaped pattern.

Third, the mechanism analysis reveals that the scale and technological effects of FDI are environmentally adverse, while the structural effect is positive but insufficient to offset the overall negative impact. This highlights the dominance of production expansion and non-green technological spillovers in shaping environmental outcomes.

Fourth, the environmental impact of FDI exhibits substantial heterogeneity across countries. Institutional quality, economic size, and environmental conditions play a critical role in determining whether FDI contributes to environmental improvement or degradation.

Overall, the empirical evidence indicates that FDI in Gulf countries remains environmentally costly in net terms. Despite limited signs of structural upgrading and conditional benefits in better-regulated economies, the dominant effects of scale expansion and inefficient technology transfer continue to drive environmental degradation.

## 6. Conclusion

This study examines the environmental impact of foreign direct investment (FDI) in Gulf countries over the period 2004–2023 within an extended Environmental Kuznets Curve (EKC) framework. By incorporating economic growth, technological development, industrial structure, and urbanization, the analysis provides a comprehensive and multidimensional assessment of the FDI–environment nexus.

The empirical results yield several key findings.

First, FDI inflows have expanded significantly across the region, accompanied by pronounced cross-country heterogeneity. While countries such as the United Arab Emirates and Saudi Arabia attract the majority of investment, others exhibit more volatile patterns. At the same time, environmental indicators—including CO<sub>2</sub> emissions and PM<sub>2.5</sub> concentrations—suggest a persistent increase in environmental pressure.

Second, the results confirm a nonlinear relationship between economic growth and environmental quality, supporting the EKC hypothesis. Environmental degradation initially intensifies with economic expansion but declines beyond a certain income threshold.

Third, FDI exhibits a dual environmental effect. Although the baseline coefficient appears positive, indicating a partial improvement in environmental quality, the mechanism analysis reveals that the overall effect of FDI is environmentally adverse. This is primarily driven by the dominance of scale expansion and the limited effectiveness of technological spillovers.

Fourth, the mechanism analysis demonstrates that the scale and technological effects of FDI contribute negatively to environmental quality, while the structural effect remains positive but insufficient to offset the aggregate environmental burden. This reflects the continued reliance on energy-intensive production and the limited diffusion of environmentally efficient technologies.

Fifth, the results reveal substantial heterogeneity across countries. Economies with stronger institutional capacity and lower resource dependence are better positioned to benefit from FDI in terms

of environmental improvement, whereas countries with weaker governance structures experience adverse environmental outcomes.

Overall, the findings indicate that, under current structural and institutional conditions, FDI in Gulf countries remains environmentally costly in net terms.

### *6.1 Policy Implications*

The empirical findings underscore the need for targeted and differentiated policy interventions to maximize the environmental benefits of foreign direct investment (FDI) while mitigating its adverse effects.

First, strengthening environmental regulation is essential to counterbalance the negative scale effects associated with FDI. Governments should implement stricter emission standards, enhance enforcement mechanisms, and adopt advanced monitoring systems to ensure compliance, particularly in energy-intensive sectors.

Second, policy frameworks should shift from attracting large volumes of FDI to prioritizing high-quality, environmentally sustainable investment. This can be achieved by providing targeted incentives—such as tax reductions, subsidies, and preferential financing—for investments in renewable energy, green technologies, and low-carbon industries.

Third, raising technology entry standards is critical. Regulatory authorities should establish clear screening mechanisms to promote the inflow of clean and energy-efficient technologies while restricting pollution-intensive production processes. This is particularly important given the evidence of weak or negative technological spillovers identified in the empirical analysis.

Fourth, enhancing domestic absorptive and innovation capacity is vital for long-term sustainability. Governments should increase investment in research and development (R&D), support human capital formation, and strengthen linkages between multinational enterprises and domestic firms to facilitate effective technology transfer.

Fifth, improving institutional quality and environmental governance remains a fundamental prerequisite. The adoption of market-based instruments such as carbon pricing mechanisms and emissions trading systems can further internalize environmental externalities and support the transition toward a low-carbon economy.

### *6.2 Future Research Directions*

Despite its contributions, this study has several limitations that open important avenues for future research.

First, future studies could utilize firm-level or sectoral data to explore the micro-level mechanisms underlying the environmental effects of FDI. Such an approach would provide deeper insights into firm behavior, technology adoption, and the heterogeneity of environmental responses across industries.

Second, the role of environmental spillovers from multinational enterprises warrants further investigation. In particular, future research should examine the conditions under which knowledge

transfer and innovation diffusion translate into environmentally beneficial outcomes, especially in the context of energy-intensive economies.

Third, incorporating more comprehensive measures of institutional quality and governance would allow for a more precise assessment of the moderating role of policy environments. This is particularly relevant given the strong heterogeneity identified in this study.

Fourth, future research could adopt more advanced econometric techniques—such as dynamic panel models, including the System Generalized Method of Moments (System GMM)—to better address potential endogeneity and capture dynamic adjustment processes.

Finally, extending the analysis to include additional contextual factors—such as geopolitical risks, resource dependence, and energy transition dynamics—would enhance both the explanatory power and policy relevance of future studies, particularly in regions undergoing structural transformation.

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