

**Foreign Direct Investment and Environmental Pollution in MENA Countries:
Evidence from Static Panel Models (1991–2023)**

الاستثمار الأجنبي المباشر والتلوث البيئي في دول منطقة الشرق الأوسط وشمال أفريقيا (MENA):
أدلة من نماذج بيانات بانل الساكنة (1991–2023)

Labeled rachida¹

¹ University of Mustapha Stambouli -Mascara (Algeria), rachida.labeled@univ-mascara.dz

Received: 13/01/2026

Accepted: 31/03/2026

Published: 31/03/2026

Abstract:

This study examines the impact of foreign direct investment (FDI) on environmental pollution in (MENA) countries during 1991–2023 using static panel-data models. Carbon dioxide (CO₂) emissions proxy pollution, with economic, energy-related, and demographic controls capturing regional structural characteristics. Pooled ordinary least squares, fixed effects, and random effects models are estimated, and Likelihood Ratio, Breusch–Pagan, and Hausman tests determine the most appropriate specification. Empirical results over the sample show a statistically significant negative association between FDI inflows and CO₂ emissions, supporting the Environmental Halo Hypothesis for MENA. Conversely, economic growth and trade openness significantly increase emissions, consistent with carbon-intensive expansion. Energy consumption and population growth are not statistically significant, while natural resource revenues are linked to lower pollution. Using an extended long-run panel and rigorous model selection, the study provides updated evidence and informs investment and environmental policies aimed at sustainable development and mitigating regional degradation.

Keywords: Foreign Direct Investment; Environmental Pollution; MENA Countries; Panel Data; CO₂ Emissions.

JEL Classification Codes: F21, Q53, C23, O13

ملخص:

تهدف هذه الدراسة إلى تحليل أثر الاستثمار الأجنبي المباشر على التلوث البيئي في دول الشرق الأوسط وشمال إفريقيا خلال الفترة 1991–2023، باستخدام نماذج بيانات بانل ساكنة ومجموعة من المتغيرات الاقتصادية والطاقيّة والديموغرافية. تمت المفاضلة بين النماذج القياسية باستخدام اختبارات LR و Breusch–Pagan و Hausman، التي بينت أن نموذج التأثيرات الثابتة هو الأكثر ملاءمة.

أظهرت النتائج وجود علاقة عكسية معنوية بين الاستثمار الأجنبي المباشر والتلوث البيئي، مما يدعم فرضية الحالة البيئية. كما تبين وجود علاقة طردية معنوية بين كل من النمو الاقتصادي والانفتاح التجاري وبين التلوث البيئي، في حين لم يكن لاستهلاك الطاقة والزيادة السكانية أثر معنوي. كما خلصت النتائج إلى علاقة عكسية معنوية بين إيرادات الموارد الطبيعية والتلوث البيئي. تؤكد الدراسة أهمية تبني سياسات بيئية وتنموية أكثر توازناً تضمن الاستفادة من الاستثمارات الأجنبية مع الحد من الانبعاثات الكربونية.

كلمات مفتاحية: الاستثمار الأجنبي المباشر؛ التلوث البيئي؛ دول منطقة الشرق الأوسط وشمال أفريقيا (MENA)؛ بيانات السلاسل الزمنية المقطعية (Panel Data)؛ انبعاثات ثاني أكسيد الكربون (CO₂).

تصنيفات JEL: F21، Q53، C23، O13

Corresponding author: labeled rachida, e-mail: rachida.labeled@univ-mascara.dz

Foreign Direct Investment and Environmental Pollution in MENA Countries: Evidence from Static Panel Models (1991–2023)

INTRODUCTION:

Over the past decades, countries in the Middle East and North Africa (MENA) region have undergone significant structural economic transformations, largely driven by policies aimed at attracting foreign direct investment (FDI) as a key engine of economic growth and development. Alongside its potential economic benefits, the increasing inflow of FDI has raised growing concerns regarding its environmental consequences, particularly in a region characterized by rapid urbanization, high energy intensity, and heterogeneous environmental regulatory frameworks.

The theoretical and empirical literature presents two competing perspectives on the relationship between FDI and environmental pollution. According to the Pollution Haven Hypothesis, multinational firms tend to relocate pollution-intensive activities to countries with relatively lax environmental regulations, thereby exacerbating environmental degradation in host economies. In contrast, the Environmental Halo Hypothesis suggests that foreign investment may improve environmental quality through the transfer of cleaner technologies, advanced managerial practices, and stricter environmental standards. The coexistence of these opposing hypotheses has generated an ongoing debate, especially in developing regions such as MENA, where institutional quality and environmental governance vary considerably across countries.

Despite the growing body of empirical research examining the FDI–environment nexus, the evidence for MENA countries remains inconclusive. While several studies report that FDI inflows contribute to increased carbon emissions, others find that foreign investment can reduce environmental pollution under specific economic or institutional conditions. These mixed findings highlight the importance of country-specific characteristics, the structure of economic growth, and the methodological approaches employed in empirical analyses.

Against this backdrop, the present study aims to investigate the impact of foreign direct investment on environmental pollution in a panel of MENA countries over the period 1991–2023. Environmental pollution is proxied by carbon dioxide (CO₂) emissions, while a set of economic, energy-related, and demographic control variables is incorporated to capture the structural determinants of emissions in the region. Static panel data techniques, including pooled ordinary least squares, fixed effects, and random effects models, are employed, and rigorous model selection procedures—namely the Likelihood Ratio, Breusch–Pagan, and Hausman tests—are used to identify the most appropriate econometric specification.

This study contributes to the existing literature in several important ways. First, it provides updated long-run empirical evidence for the MENA region using an extended dataset covering more than three decades, a period that remains underexplored in previous regional studies. Second, by systematically applying multiple model selection tests, the analysis enhances the robustness and reliability of the estimated results. Finally, the findings offer relevant policy insights for policymakers seeking to balance the objectives of attracting foreign investment and achieving environmental sustainability, particularly in economies that continue to rely heavily on carbon-intensive growth patterns.

The remainder of the paper is structured as follows. Section 2 reviews the theoretical and empirical literature on foreign direct investment and environmental pollution. Section 3 describes the data, variables, and econometric methodology. Section 4 presents and discusses

the empirical results. Section 5 concludes with a summary of the main findings and policy implications.

1- Review of theoretical and applied literature:

1-1 Basic theoretical concepts:

1-1-1 Foreign Direct Investment (FDI): Refers to the inflow of foreign capital into a country with the purpose of investing in productive economic sectors, typically accompanied by the transfer of knowledge and technology (Patterson, 2004).

1-1-2 Pollution Haven: This theory proposes that industries responsible for pollution often move from nations with environmental laws to countries where regulations are more relaxed, resulting in higher emissions in the destination countries (Copeland, 2013).

1-1-3 Environmental Halo Effect: This theory assumes that foreign direct investment may sometimes contribute to enhancing environmental efficiency in the host country through the transfer of clean technologies and modern management practices (Temurshoev, 2006).

1-2 Empirical Studies

The relationship between foreign direct investment (FDI) and environmental pollution in the Middle East and North Africa (MENA) region has received increasing attention, particularly in the context of the Pollution Haven Hypothesis (PHH) and the Environmental Kuznets Curve (EKC). Empirical evidence from recent studies generally indicates that FDI inflows have contributed to environmental degradation and increased pollution in most countries of the region, thereby supporting the PHH, especially in contexts characterized by poor institutional quality and ineffective ecological regulations (Abdo et al., 2020; Abdouli & Hammami, 2017; Gorus & Aslan, 2019; Mahmood et al., 2023; Pereira et al., 2021; Taşdemir & Özçelik, 2023).

However, the relationship remains complex. Some studies show that FDI can help reduce emissions under specific conditions, such as when countries reach higher levels of economic development or possess strong governance systems and advanced human capital (Bouchoucha, 2024; Guoyan et al., 2022; Kahia et al., 2019; Saeed et al., 2024; Salehnia et al., 2020; Tabash et al., 2023; Taşdemir & Özçelik, 2023). Moreover, sectoral differences, energy consumption patterns, and the role of technology transfer further complicate the FDI–pollution nexus (Abdo et al., 2020; Ayad et al., 2023; Kahia et al., 2019; Mahmood et al., 2023; Zhuang et al., 2023).

The literature also highlights the importance of policy interventions such as promoting clean technologies and strengthening institutional frameworks as key strategies to mitigate the negative environmental impacts of FDI (Bouchoucha, 2024; Saeed et al., 2024; Tabash et al., 2023; Taşdemir & Özçelik, 2023). Overall, while FDI has, in many cases, exacerbated pollution in the MENA region, its impact is determined by a combination of economic, institutional, and sector-specific factors.

Foreign Direct Investment and Environmental Pollution in MENA Countries: Evidence from Static Panel Models (1991–2023)

1-2-1 Foreign Direct Investment and Pollution: General Trends in the Region

Most studies show that foreign direct investment inflows are associated with increased environmental pollution in Middle East and North African countries, particularly through the rise in carbon dioxide emissions and other pollutants (Abdo et al., 2020; Abdouli & Hammami, 2017; Gorus & Aslan, 2019; Mahmood et al., 2023; Pereira et al., 2021; Taşdemir & Özçelik, 2023). This supports the Pollution Haven Hypothesis, which assumes that multinational companies may relocate polluting industries to countries with more lenient environmental regulatory standards.

1-2-2 Nonlinear Effects Related to Conditions

Several studies indicate the existence of nonlinear relationships between foreign direct investment and pollution. For example, FDI may lead to increased emissions in the early stages of development. However, it can contribute to pollution reduction once a specific economic or institutional level is reached, supporting a more refined version of the Environmental Kuznets Curve (Ayad et al., 2023; Bouchoucha, 2024; Guoyan et al., 2022; Kahia et al., 2019; Salehnia et al., 2020; Taşdemir & Özçelik, 2023).

The relationship is also mediated by other factors, such as human capital, governance, and the sectoral composition of the economy (Bouchoucha, 2024; Tabash et al., 2023; Taşdemir & Özçelik, 2023).

1-2-3 The Role of Institutional Quality and Governance

Good governance and strong institutional frameworks can mitigate the negative environmental impacts of foreign direct investment. Studies indicate that in countries within the region that possess high-quality institutions, the adverse effects of foreign direct investment on pollution are reduced. Moreover, foreign direct investment can contribute to improving environmental performance (Bouchoucha, 2024; Tabash et al., 2023; Taşdemir & Özçelik, 2023).

1-2-4 Sectoral and Spatial Effects

The impact of foreign direct investment varies across sectors, as pollution-intensive industries such as mining, construction, and chemicals contribute more significantly to environmental degradation (Abdo et al., 2020; Mahmood et al., 2023). Spatial economic analyses further show that pollution associated with foreign direct investment may spill over into neighboring countries, although these effects are often statistically insignificant (Abdo et al., 2020; Mahmood et al., 2023).

Most empirical evidence suggests that foreign direct investment has generally led to increased pollution in Middle East and North Africa countries, particularly in contexts characterized by weak environmental regulations and low institutional quality (Abdo et al., 2020; Abdouli &

Hammami, 2017; Gorus & Aslan, 2019; Mahmood et al., 2023; Pereira et al., 2021; Taşdemir & Özçelik, 2023). However, this relationship is not uniform. In countries or sectors with stronger governance, higher levels of human capital, or more advanced stages of economic development, foreign direct investment can result in neutral or even positive environmental outcomes, thereby supporting the “pollution halo” hypothesis in certain contexts (Bouchoucha, 2024; Kahia et al., 2019; Saeed et al., 2024; Salehnia et al., 2020; Tabash et al., 2023; Taşdemir & Özçelik, 2023).

In addition, the sectoral concentration of investment, such as investment in resource extraction versus technology-intensive industries, and the adoption of clean technologies, are key determinants of the environmental impact of foreign direct investment (Abdo et al., 2020; Ayad et al., 2023; Kahia et al., 2019; Mahmood et al., 2023; Zhuang et al., 2023). Methodological differences, such as the use of panel data, spatial econometric models, and nonlinear models, also contribute to variations in findings across studies.

Overall, policy interventions that strengthen environmental regulations, promote clean technologies, and improve institutional quality are essential to ensuring that foreign direct investment contributes to sustainable development in the region (Bouchoucha, 2024; Saeed et al., 2024; Tabash et al., 2023; Taşdemir & Özçelik, 2023).

The literature reveals that foreign direct investment has generally contributed to increased pollution in Middle East and North Africa countries, especially in environments marked by weak environmental regulations and poor institutional quality. However, this relationship is complex and is mediated by factors such as economic development, governance, sectoral concentration, and technology transfer. Policies that strengthen institutions and encourage clean technologies are therefore crucial for harnessing the benefits of foreign direct investment while minimizing its environmental costs.

2- Applied Study

In this section, the impact of foreign direct investment on environmental pollution in MENA countries is analyzed using a sample of MENA countries from 1990 to 2023. Given the nature of the available data, which combines time-series and cross-sectional data, static panel data models will be used, as they are among the most prominent econometric models suitable for this type of data.

2-1 Sample and Study Variables

The study sample consists of 12 countries from the Middle East and North Africa (MENA) region. These countries were selected based on the criterion of availability of complete data for the variables under investigation over the time period from 1990 to 2023 (as shown in Appendix 1). The variables included in the model were identified for their theoretical relevance and close connection to the research topic. They were also drawn from a wide range of previous studies in this field. The variables used in the analysis are described as follows:

Foreign Direct Investment and Environmental Pollution in MENA Countries: Evidence from Static Panel Models (1991–2023)

2-1-1 Dependent variable (Environmental pollution):

To represent the dependent variable related to environmental pollution, carbon dioxide emissions were used. This variable is denoted by the symbol (CDE).

2-1-2 Independent variable (Foreign direct investment):

To capture the independent variable representing foreign direct investment, net inflows of foreign direct investment were employed. This variable is denoted by the symbol (FDI).

2-1-3 Control variables:

In addition to the dependent and independent variables, a set of control variables was included to neutralize the effects of external factors and ensure that the model estimators are unbiased, thereby enhancing the internal validity of the estimated relationships. These control variables are as follows:

- **Economic growth:**
GDP per capita is used as an operational measure of economic growth in the model. This variable is denoted by (GDPP).
- **Energy consumption:**
This variable, which reflects the intensity of resource use, is represented by primary energy consumption and is denoted by (EC).
- **Trade openness:**
For analytical purposes, this variable is calculated as the ratio of total exports and imports to gross domestic product and is denoted by (TR).
- **Population growth:**
This variable is defined as the annual population growth rate and is included to reflect demographic changes affecting the model. It is denoted by (POP).
- **Natural resources:**
This key variable is measured as the ratio of total natural resource revenues to gross domestic product and is denoted by (NRR).

Table (1): Definition of variables used in the study

Variables	Definition of Variables	Symbol	Unit	Source
Dependent variable	Carbon dioxide emissions (environmental pollution)	CDE	Million tons	World Bank website
Independent variable	Net inflows of foreign direct investment	FDI	Percentage (%)	
Control variables	GDP per capita	GDPP	Percentage (%)	
	Primary energy consumption	EC	Percentage (%)	
	Total exports and imports as a percentage of gross domestic product	TR	Percentage (%)	

Labeled rachida

	Population growth	POP	Percentage (%)	
	Total natural resource revenues to gross domestic product	NRR	Percentage (%)	

Source: Prepared by the researcher based on World Bank data; date of access: 15/10/2025. Available at: <https://data.albankaldawli.org/>

2-2 Construction of the Econometric Model of the Study

The study is based on an integrated analytical framework that measures the impact of foreign direct investment on environmental pollution for a sample of countries in the Middle East and North Africa (MENA) region, to test the pollution haven hypothesis. The variables were carefully selected based on the relevant literature and previous studies addressing this issue, while taking into account the specific characteristics of the research sample—namely the countries of the Middle East and North Africa (MENA) region—and the availability of data.

This framework constitutes the basis for constructing the econometric model. Carbon dioxide emissions (environmental pollution) (CDE) are specified as the dependent variable, while net inflows of foreign direct investment (FDI) are adopted as the independent variable. The control variables include GDP per capita (GDPP), primary energy consumption (EC), total exports and imports as a percentage of gross domestic product (TR), population growth (POP), and total natural resource revenues as a percentage of gross domestic product (NRR). The general linear mathematical form of the model can be expressed as follows:

$$CDE_{it} = c + \beta_{1j} FDI_{j(it)} + \beta_{2j} GDPP_{j(it)} + \beta_{3j} EC_{j(it)} + \beta_{4j} TR_{j(it)} + \beta_{5j} POP_{j(it)} + \beta_{6j} NRR_{j(it)} + \varepsilon_{it}$$

Where (β_{kj}) represent the model parameters, $(i = 1, \dots, n)$ denotes the cross-sectional units (countries), $(t = 1, \dots, T)$ represents the time dimension, and ε_{it} denotes the random error term.

2-3 Estimation of the Study Model

To obtain accurate results and ensure sound interpretation, the study relies on a set of static panel data models. These models include the Pooled Ordinary Least Squares (Pooled OLS), Random Effects, and Fixed Effects models, using panel data on a sample of countries from the Middle East and North Africa (MENA) region.

Table (2): Results of Estimating Static Panel Models

Variables	Estimated Models		
	Pooled OLS	Fixed Effects	Random Effects
Constant	48.61101*	12.88309*	17.36994*
FDI	-0.417254*	-0.287628*	-0.298393*
GDPP	0.000259*	0.000408*	0.000409*
EC	-1.685057*	-0.035422	-0.373713
TR	-0.308651*	0.080695*	0.023985

Foreign Direct Investment and Environmental Pollution in MENA Countries: Evidence from Static Panel Models (1991–2023)

POP	0.160862*	-0.058331	-0.002067
NRR	-0.183309*	-0.275690*	-0.229488*
F-statistic	80.47231* (0.000000)	126.3310 (0.000000)	29.88099 (0.000000)
R-squared	0.548155	0.847315	0.310567
DW statistic	0.166972	0.201527	0.187595

(*) Statistical significance at 5%

Source: Prepared by the researcher based on the outputs of Eviews 12

Table 02 presents the results of estimating the three static panel data models, namely the Pooled OLS, Fixed Effects, and Random Effects models, using data from a sample of countries in the Middle East and North Africa (MENA) region. In the Pooled OLS model, all explanatory variables are statistically significant, and the F-statistic's probability value indicates the overall statistical significance of the model ($P < 0.05$).

In the Fixed Effects model, all explanatory variables are statistically significant, as indicated by the probability values of their coefficients ($P < 0.05$), except primary energy consumption (EC) and total exports and imports as a percentage of GDP (TR), whose coefficients are not statistically significant ($P > 0.05$). The probability value of the Fisher statistic also confirms the model's overall statistical significance ($P < 0.05$).

As for the Random Effects model, there is noticeable variation in the statistical significance of the explanatory variables. The variables net inflows of foreign direct investment (FDI), GDP per capita (GDPP), and total natural resource revenues as a percentage of GDP (NRR) are statistically significant, as their probability values are below the conventional significance level ($P < 0.05$). In contrast, the remaining variables are not statistically significant, as their coefficient probabilities exceed this threshold ($P > 0.05$). Nevertheless, this model is statistically significant, as indicated by the Fisher statistic ($P < 0.05$).

Regarding the models' explanatory power, as assessed by the coefficient of determination (R^2), the Fixed Effects model yields the highest value, 0.847315, indicating a strong ability to explain variation in the dependent variable (environmental pollution). This performance exceeds that of the Pooled OLS model, which exhibits moderate explanatory power, and the Random Effects model, which shows relatively low explanatory power. Based on this comparison, the Fixed Effects model appears to be the most appropriate and initially the most reliable framework for analyzing the impact of foreign direct investment on environmental pollution in this study, pending the formal comparison among the three models and the final selection of the model best suited to the study data.

2-4 Model Comparison Tests:

After discussing the estimation of the three stationary panel models, it is necessary to move to the next step: compare these models using comparison methods and a set of tests to choose the

most suitable model for the study. The analysis and discussion will then be conducted according to this model. For this purpose, the Likelihood Ratio test is used to compare the two models: a pooled regression model and a fixed-effects model. This test is based on the following two assumptions:

H0: The appropriate model is the Pooled OLS model

H1: The appropriate model is the Fixed Effects model.

The following table presents the results of the Likelihood Ratio test.

Table (3): Likelihood Ratio Test

Effects Test	Statistic	d.f	Prob
Cross-section F	68.932493	(11.387)	0.0000
Cross-section Chi-square	439.408807	11	0.0000

Source: Prepared by the researcher based on the outputs of Eviews 12.

The results of the Likelihood Ratio test, which includes the results of Fisher's Constrained Test (F) and the Chi-squared Test (X2) for comparing the pooled regression and random effects models, show that the fixed effects model is the most suitable, as the probability value for both tests was 0.000, which is less than 5%. After comparing the pooled regression and fixed effects models, we move on to comparing the pooled regression and random effects models, using the Breusch-Pagan test, which is based on the following two assumptions:

H0: The appropriate model is the Pooled OLS model

H1: The appropriate model is the Fixed Effects model.

The following table shows the results of the LM Breusch-Pagan test:

Table (4): LM Breusch-Pagan Test

Test Hypothesis			
	Cross-section	Time	Both
Breusch-Pagan	1144.275	1.421091	1145.697
Prob.	(0.0000)	(0.2332)	(0.0000)

Source: Prepared by the researcher based on the outputs of Eviews 12.

Table (04) above shows that Prob < 5%, which necessitates accepting the alternative hypothesis that the random effects model is the most suitable. Therefore, we proceed to the next step: comparing the random-effects model with the fixed-effects model. To compare the fixed- and random-effects models, the Hausman test will be performed. Although standard analysis texts indicate that the fixed-effects model is most suitable for cross-border data across countries, this cannot be confirmed without using the Hausman test. This test aims to determine which effects are more appropriate for estimating the model, whether fixed or random effects, in order to decide which model should be chosen. We use this test to compare the fixed and random effects models based on the assumptions upon which it is based. If the probability is greater than 0.05, we accept the H0 hypothesis; if the probability is less than 0.05, we accept the H1 hypothesis. The assumptions for this test are given as follows:

Foreign Direct Investment and Environmental Pollution in MENA Countries: Evidence from Static Panel Models (1991–2023)

H0: The appropriate model is the Pooled OLS model

H1: The appropriate model is the Fixed Effects model.

The following table shows the results of the Husman test:

Table (5): Results of the Husman Test

Test Summary	Chi-Sq Statistic	Chi-Sqdf	Prob
Cross-section random	31.147852	6	0.0000

Source: Prepared by the researcher based on the outputs of Eviews 12.

Based on the Hausman test results, which indicate a probability value of 0.0000 (less than 0.05), the null hypothesis is rejected, and the alternative hypothesis is accepted. This implies that the Fixed Effects model is the most appropriate for analyzing the data from the sample countries in the Middle East and North Africa (MENA) region.

2-5 Discussion of the findings:

The results of the fixed effects model are considered optimal for analyzing the relationship between variables in a sample of countries in the Middle East and North Africa (MENA) region. Based on these results, the estimated fixed effects model can be formulated as follows:

$$\begin{aligned} \text{CDE}_{it} = & 12.88309 - 0.287628\text{FDI}_{j(it)} + 0.000408 \text{GDPP}_{j(it)} - 0.035422 \text{EC}_{j(it)} \\ & + 0.080695\text{TR}_{j(it)} - 0.058331 \text{POP}_{j(it)} - 0.275690 \text{NRR}_{j(it)} + \varepsilon_{it} \end{aligned}$$

Based on the foregoing, the Fixed Effects model is the most appropriate for this study. Accordingly, the results and conclusions are discussed and interpreted within the framework of this model and can be summarized as follows:

- The estimated coefficient of the constant term indicates that when the values of the independent variables are zero, the dependent variable takes a value of approximately 12.88309. This coefficient is statistically significant, as $P < 0.05$.
- There exists a statistically significant inverse relationship between net inflows of foreign direct investment (FDI) and carbon dioxide emissions (CDE), as reflected by the negative sign of the FDI coefficient and its probability value ($P < 0.05$). This result provides evidence for rejecting the Pollution Haven Hypothesis (PHH) for the sample of MENA countries. Instead, it strongly supports the Halo Effect hypothesis, which can be economically interpreted as indicating that foreign direct investment contributes to improving environmental quality through the transfer of more efficient and cleaner production technologies, as well as the imposition of stricter international managerial and environmental standards. These mechanisms generate a positive indirect effect that contributes to reducing overall pollution levels in the host region.

- There is a statistically significant positive relationship between GDP per capita (GDPP) and carbon dioxide emissions (CDE), as indicated by the positive sign of the GDP per capita coefficient and its probability value ($P < 0.05$). This suggests that economic expansion within the sample of MENA countries is associated with a significant increase in environmental pollution levels. This relationship can be attributed to the characteristics of an early stage of economic growth and to high energy intensity, in which prevailing production patterns rely heavily on fossil fuels. The result confirms that countries in the region are located on the upward-sloping segment of the Environmental Kuznets Curve (EKC), indicating that current economic growth is environmentally unsustainable due to weak environmental regulations relative to the priority given to development and economic objectives.
- There exists a negative but statistically insignificant relationship between primary energy consumption (EC) and carbon dioxide emissions (CDE), as reflected by the negative sign of the energy consumption coefficient and its probability value ($P > 0.05$). This result indicates that although the direction of the relationship suggests a tendency toward reduced emissions (efficiency), increases in energy consumption do not exert a statistically reliable effect on pollution levels. The lack of significance can be explained by the fact that changes in energy consumption patterns or efficiency improvements in the MENA countries are methodologically insufficient to alter the overall energy mix or to achieve a substantial and observable reduction in emissions. Consequently, primary energy consumption appears to play a neutral role in explaining overall fluctuations in carbon dioxide emissions.
- A statistically significant positive relationship is observed between trade openness (TR), measured as the ratio of total exports and imports to GDP, and carbon dioxide emissions (CDE), as indicated by the positive coefficient sign and a probability value ($P < 0.05$). This relationship can be economically interpreted through scale and composition effects; whereby increased trade activity leads to higher carbon-intensive production and the expansion of polluting logistics and maritime transport activities. It may also reflect a failure to implement stringent environmental standards alongside trade liberalization, implying that the economic gains from trade in MENA countries come at the cost of environmental degradation, as evidenced by higher carbon emissions.
- There is a negative but statistically insignificant relationship between population growth (POP) and carbon dioxide emissions (CDE), as shown by the negative coefficient sign and its probability value ($P > 0.05$). This confirms the absence of a statistically reliable effect of population growth on pollution levels in MENA countries. This neutral statistical effect suggests that more powerful determinants of emissions are structural economic factors such as income levels and technology (FDI), which outweigh the direct impact of population growth. Although population growth is included as a control variable, its lack of statistical significance precludes drawing definitive conclusions about its direct role as an independent driver of changes in aggregate emissions.
- A statistically significant negative relationship exists between total natural resource revenues as a percentage of GDP (NRR) and carbon dioxide emissions (CDE), as indicated by the negative coefficient sign and a probability value ($P < 0.05$). This finding suggests that greater reliance on natural resource revenues in MENA countries is associated with a statistically significant reduction in pollution levels. Economically, this relationship can be interpreted as indicating that natural resource revenues provide the financial liquidity necessary

Foreign Direct Investment and Environmental Pollution in MENA Countries: Evidence from Static Panel Models (1991–2023)

to finance transitions toward cleaner infrastructure. It may also reflect the fact that economies dominated by extractive sectors (oil and gas) tend to apply relatively advanced technical standards, often influenced by foreign direct investment, which helps mitigate environmental pressures compared to development paths based on highly polluting manufacturing activities.

Conclusion and Policy Implications

This study examined the impact of foreign direct investment on environmental pollution in Middle East and North African (MENA) countries over the period 1991–2023, using static panel data techniques. By employing pooled ordinary least squares, fixed effects, and random effects models, and relying on rigorous model selection tests, the analysis provides robust empirical evidence on the nature of the relationship between foreign investment and environmental quality in the region.

The empirical findings indicate a statistically significant negative relationship between foreign direct investment inflows and carbon dioxide emissions, thereby supporting the Environmental Halo Hypothesis in the MENA context. This result suggests that foreign investment may contribute to improving environmental performance through channels such as technology transfer, enhanced production efficiency, and the adoption of higher environmental standards. In contrast, economic growth and trade openness are found to exert a significant positive effect on environmental pollution, reflecting the carbon-intensive nature of growth patterns and trade-related activities in the region. Energy consumption and population growth do not exhibit statistically significant effects, while natural resource revenues appear to play a mitigating role in reducing pollution levels.

These findings carry several important policy implications. First, policymakers in MENA countries should continue to promote foreign direct investment, particularly in sectors characterized by higher technological intensity and cleaner production processes. Strengthening environmental regulations and investment screening mechanisms can help ensure that incoming foreign investments align with national sustainability objectives and do not exacerbate environmental degradation.

Second, the positive association between economic growth, trade openness, and environmental pollution highlights the need to integrate environmental considerations into broader development and trade policies. Economic expansion strategies should be complemented by stricter environmental standards, carbon mitigation policies, and incentives for low-emission production, especially in trade-exposed and energy-intensive sectors.

Third, although energy consumption does not show a statistically significant impact on emissions in this study, the results emphasize the importance of accelerating the transition toward cleaner and more efficient energy systems. Expanding renewable energy capacity, improving energy efficiency, and reducing dependence on fossil fuels remain essential components of long-term environmental sustainability in the region.

Finally, the negative relationship between natural resource revenues and environmental pollution suggests that resource rents can be strategically utilized to finance environmental infrastructure and green investments. Allocating a portion of these revenues to clean

technologies, environmental monitoring systems, and sustainable development initiatives can enhance environmental outcomes and support a more balanced development trajectory.

Overall, the study underscores the importance of adopting integrated investment, trade, and environmental policies to ensure that economic development in MENA countries proceeds in a sustainable and environmentally responsible manner. Future research may extend the present analysis by incorporating dynamic econometric techniques, additional environmental indicators, or institutional quality measures to further explore the complex interactions between foreign investment and environmental sustainability.

Bibliography List:

1. Abdo, A.-B., Li, B., Zhang, X., Lu, J., & Rasheed, A. (2020). Influence of FDI on environmental pollution in selected Arab countries: a spatial econometric analysis perspective. *Environmental Science and Pollution Research*, 27(22), 28222–28246. <https://doi.org/10.1007/s11356-020-08810-4>
2. Abdouli, M., & Hammami, S. (2017). Economic growth, FDI inflows, and their impact on the environment: an empirical study for the MENA countries. *Quality & Quantity*, 51(1), 121–146. <https://doi.org/10.1007/s11135-015-0298-6>
3. Ayad, H., Lefilef, A., Jahanger, A., & Balsalobre-Lorente, D. (2023). Reinvestigate the Effect of Foreign Direct Investment on Environmental Quality in the MENA Region: Is There Any Difference Using the Load Capacity Factor? *Journal of the Knowledge Economy*, 15(3), 14810–14840. <https://doi.org/10.1007/s13132-023-01629-7>
4. Bouchoucha, N. (2024). Does Institutional Quality Mitigate the Effect of Foreign Direct Investment on Environmental Quality: Evidence from MENA Countries. *Journal of the Knowledge Economy*, 15(4), 16187–16205. <https://doi.org/10.1007/s13132-023-01606-0>
5. Copeland, B. (2013). *The Pollution Haven Hypothesis*.
6. Gorus, M. S., & Aslan, M. (2019). Impacts of economic indicators on environmental degradation: Evidence from MENA countries. *Renewable and Sustainable Energy Reviews*, 103, 259–268. <https://doi.org/10.1016/j.rser.2018.12.042>
7. Guoyan, S., Khaskheli, A., Raza, S. A., & Shah, N. (2022). Analyzing the association between foreign direct investment and carbon emissions in MENA countries: a pathway to sustainable development. *Environment, Development and Sustainability*, 24(3), 4226–4243. <https://doi.org/10.1007/s10668-021-01613-8>
8. Kahia, M., Ben Jebli, M., & Belloumi, M. (2019). Analysis of the impact of renewable energy consumption and economic growth on carbon dioxide emissions in 12 MENA countries. *Clean Technologies and Environmental Policy*, 21(4), 871–885. <https://doi.org/10.1007/s10098-019-01676-2>
9. Mahmood, H., Saqib, N., Adow, A. H., & Abbas, M. (2023). FDI, exports, imports, and consumption-based CO2 emissions in the MENA region: spatial analysis. *Environmental Science and Pollution Research*, 30(25), 67634–67646. <https://doi.org/10.1007/s11356-023-27245-1>
10. Patterson, N. K. (2004). *Foreign direct investment: trends, data availability, concepts, and recording practices*. International Monetary Fund.
11. Pereira, V., Moosa, I. A., Ramiah, V., & Temouri, Y. (2021). The Environmental Effects of FDI. *Journal of Global Information Management*, 29(6), 1–22. <https://doi.org/10.4018/JGIM.291512>
12. Saeed, U. F., Twum, A. K., & Klugah, G. E. (2024). Navigating Carbon Peaking and Neutrality in MENA: The Impact of Foreign Direct Investment and Trade Openness Using Panel PCSE

Foreign Direct Investment and Environmental Pollution in MENA Countries: Evidence from Static Panel Models (1991–2023)

- and FGLS Techniques. *Environmental Quality Management*, 34(2). <https://doi.org/10.1002/tqem.22352>
13. Salehnia, N., Karimi Alavijeh, N., & Salehnia, N. (2020). Testing Porter and pollution haven hypothesis via economic variables and CO2 emissions: a cross-country review with panel quantile regression method. *Environmental Science and Pollution Research*, 27(25), 31527–31542. <https://doi.org/10.1007/s11356-020-09302-1>
 14. Tabash, M. I., Farooq, U., El Refae, G. A., & Belarbi, A. (2023). Tackling the ecological footprints of foreign direct investment and energy dependency through governance: empirical evidence from the GCC region. *Quality & Quantity*, 57(5), 4435–4454. <https://doi.org/10.1007/s11135-022-01534-2>
 15. Taşdemir, F., & Özçelik, S. E. (2023). Do human capital and governance thresholds matter for the environmental impact of FDI? The evidence from MENA countries. *Environmental Science and Pollution Research*, 30(14), 41741–41754. <https://doi.org/10.1007/s11356-023-25188-1>
 16. Temurshoev, U. (2006). *Working Paper Series 292 (ISSN 1211-3298) Pollution Haven Hypothesis or Factor Endowment Hypothesis: Theory and Empirical Examination for the US and China*.
 17. Zhuang, Y., Yang, S., Razzaq, A., & Khan, Z. (2023). Environmental impact of infrastructure-led Chinese outward FDI, tourism development, and technology innovation: a regional country analysis. *Journal of Environmental Planning and Management*, 66(2), 367–399. <https://doi.org/10.1080/09640568.2021.1989672>

Appendices:

Appendix (1): Sample of Countries Used in the Study

No.	Code	Country	No.	Code	Country
01	ALG	Algeria	07	IRN	Iran
02	TUN	Tunisia	08	BHR	Bahrain
03	MAR	Morocco	09	IRQ	Iraq
04	EGY	Egypt	10	OMN	Oman
05	JOR	Jordan	11	QAT	Qatar
06	SAU	Saudi Arabia	12	KWT	Kuwait

Source: Prepared by the researcher.

Appendix (2): Results of the Pooled Regression Model Estimation

Dependent Variable: CDE

Method: Panel Least Squares

Date: 10/17/25

Time: 02:17

Sample: 1990–2023

Periods included: 34

Labeled rachida

Cross-sections included: 12

Total panel (unbalanced) observations: 405

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FDI	-0.417254	0.205981	-2.025696	0.0435
GDPP	0.000259	3.97E-05	6.519048	0.0000
EC	-1.685057	0.147185	-11.44854	0.0000
TR	-0.330851	0.022061	-13.99062	0.0000
POP	0.160862	0.030633	5.251186	0.0000
NRR	-0.183309	0.056050	-3.270431	0.0012
C (Constant)	48.61101	2.431758	19.99007	0.0000
Root MSE: Mean dependent variable: S.D. dependent variable: Akaike information criterion: Schwarz criterion: Hannan-Quinn criterion: Durbin-Watson stat:	11.64085 17.36352 17.33911 7.81486 7.85087 7.80877 0.166972	R-squared: Adjusted R-squared: Standard Error of Regression: Sum squared residuals: Log likelihood: F-statistic: Prob(F-statistic):		0.548155 0.541344 11.74277 548187.2 -1568.751 80.47231 0.000000

Source: Prepared by the researcher based on EViews 12 output.

Appendix (3): Results of the Fixed Effects Model Estimation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FDI	-0.287628	0.126567	-2.272537	0.0236
GDPP	0.000408	3.40E-05	11.99382	0.0000
EC	-0.035422	0.237330	-0.149254	0.8814
TR	0.080495	0.031081	2.596278	0.0098
POP	-0.058331	0.038824	-1.502462	0.1338
NRR	-0.257609	0.049958	-5.518421	0.0000
C (Constant)	12.88039	2.675177	4.815791	0.0000
Root MSE: Mean dependent variable: S.D. dependent variable: Akaike information criterion: Schwarz criterion: Hannan-Quinn criterion: Durbin-Watson stat:	6.768881 17.36352 17.33911 6.758043 6.892797 6.821238 2.01527	R-squared: Adjusted R-squared: Standard Error of Regression: Sum squared residuals: Log likelihood: F-statistic: Prob(F-statistic):		0.847315 0.840068 6.922462 154545.2 1349.046 126.3310 0.000000

Source: Prepared by the researcher based on the outputs of Eviews 12.

Foreign Direct Investment and Environmental Pollution in MENA Countries: Evidence from Static Panel Models (1991–2023)

Appendix (4): Results of the Random Effects Model Estimation

Dependent Variable: CDE

Method: Panel EGLS (Cross-section random effects)

Date: 10/17/25

Time: 02:19

Sample: 1990–2023

Periods included: 34

Cross-sections included: 12

Total panel (unbalanced) observations: 405

Estimator: Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FDI	-0.298393	0.126369	-2.361275	0.0187
GDPP	0.000409	3.35E-05	12.20200	0.0000
EC	-0.373713	0.216934	-1.722701	0.0857
TR	0.023985	0.028993	0.827294	0.4086
POP	-0.000267	0.036701	-0.056328	0.9551
NRR	-0.229488	0.048153	-4.765823	0.0000
C (Constant)	17.36994	3.879429	4.477447	0.0000
Effect specification			Standard Deviation (S.D.)	Rho
Cross-section random			10.15182	0.6826
Idiosyncratic random			6.922462	0.3174
Weighted Statistics				
Root MSE	7.076852		R-squared	0.310567
Mean dependent var	2.033668		Adjusted R-squared	0.300174
S.D. dependent var	8.553940		S.E. of regression	7.138819
Sum squared resid	20283.14		F-statistic	29.8009
Durbin-Watson stat	0.187595		Prob(F-statistic)	0.000000
Unweighted Statistics				
R-squared	-0.055687		Mean dependent var	17.36352
Sum squared resid	128224.3		Durbin-Watson stat	0.029675

Source: Prepared by the researcher based on the outputs of Eviews 12.

Appendix (5): Likelihood Ratio Test Results

Redundant Fixed Effects Tests				Untitled
Equation:				
Test cross-section fixed effects				
Effects Test	Statistic	d.f.	Prob.	
Cross-section F	68.932493	(11, 387)	0.0000	
Cross-section Chi-square	439.408807	11	0.0000	

Source: Prepared by the researcher based on the outputs of Eviews 12.

Appendix (6): LM Breush-Pagan Test Results

Source: Prepared by the researcher based on the outputs of Eviews 12.

Lagrange Multiplier Tests for Random Effects

Null hypotheses: No effects

Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives

Lagrange Multiplier Tests for Random Effects			
Null hypotheses: No effects			
Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives			
Test Hypothesis			
	Cross-section	time	both
Breusch-Pagan	1144.275	1.421091	1145.697
	(0.0000)	(0.2332)	(0.0000)

Appendix (7): Husman Test Results

Correlated Random Effects – Hausman Test			
Equation: Untitled			
Test cross-section random effects			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	31.147852	6	0.0000

Source: Prepared by the researcher based on the outputs of Eviews 12.