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DO TRADE OPENNESS AND FOREIGN DIRECT INVESTMENT AFFECT CO_2 EMISSIONS IN THE MENA REGION? NEW EVIDENCE FROM A PANEL ARDL REGRESSION

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ABSTRACT: This study explores the impact of trade openness and foreign direct investment on CO2 emissions in the MENA region, providing new insights through the Panel ARDL regression. It aids policymakers in balancing economic growth and environmental sustainability. The study employs a Panel ARDL regression model to analyse the dynamic relationship between trade openness, FDI, and CO2 emissions. The study finds robust long-run relationships between Trade Openness, FDI, electricity uses and CO2 emissions, while trade openness reduces emissions. Short-run coefficients vary, with electricity use and growth significantly increasing emissions. The Error Correction Term confirms equilibrium restoration, with 23% of deviations corrected annually. FDI-driven industrial activities and fossil fuel reliance are key contributors to emissions, highlighting the need for cleaner energy sources and stricter environmental policies to mitigate climate impact. The findings guide policymakers in balancing economic growth and environmental sustainability, emphasising the need for cleaner industries, stricter regulations, and investment in renewable energy to reduce CO2 emissions in the MENA region. This study adds value by providing new empirical evidence on the dynamic impact of FDI, trade openness, and economic factors on CO2 emissions in the MENA region using the robust Panel ARDL model.

KEYWORDS: Trade Openness, Foreign Direct Investment, CO2 Emissions, MENA, Panel ARDL Model

Introduction

The increasing rate of environmental challenges threatens ecosystems and human welfare. These range from loss of biodiversity and dwindling natural resources to rising temperatures and extreme weather events (David et al., 2024). At the centre of these issues lies climate change, one of the most urgent problems for society, scientists, and policymakers. Countries and international organisations rally for the development and protection of environmental and climate enhancement as vital elements for ensuring a secure and prosperous future (Soergel et al., 2021). Sustainable development considers meeting the needs of the present while guaranteeing the ability of future generations to meet their needs. It aims to strike a balance between economic growth, ecological sustainability, and social equity (Henderson & Loreau, 2023). Achieving this balance is very challenging, especially because of the contributions of anthropogenic activities to the emissions of greenhouse gases. The large GHG emitters include CO2, CH4, and N2O, which are mainly released from industrial processes, transportation, deforestation, and the burning of fossil fuels. These gases enhance the natural greenhouse effect, leading to a rise in global temperatures and climatic change (Filho et al., 2023).

Foreign direct investment (FDI) plays a vital role in economic growth, especially in developing countries. FDI provides essential funding, technology transfer, managerial skills, and entry to international markets, which are critical for economic development (Wang et al., 2022). It is often regarded as a cornerstone of development strategies for nations aiming to accelerate growth, create jobs, and improve living standards (Paul & Feliciano-Cestero, 2021). However, there is significant debate over FDI's contribution to sustainable development. Proponents argue that FDI can stimulate economic growth by injecting capital into various sectors, transferring advanced technologies, and enhancing managerial expertise. These contributions can increase employment, productivity, and competitiveness. Additionally, FDI can integrate developing countries into the global economy, enabling them to benefit from international investment and trade networks (Joo & Shawl, 2023; Filippi et al., 2023). Critics, however, highlight potential negative impacts. One concern is that FDI may displace local investments, with multinational corporations dominating domestic markets and limiting growth opportunities for local businesses (Antonietti & Mondolo, 2023). FDI can also increase imports, straining the balance of payments and contributing to inflation. Apart from economic factors, the environmental impact of FDI is a major concern. A large share of FDI goes into industries such as mineral extraction, petrochemical processing, cement manufacturing, and oil and gas production – industries often associated with environmental degradation. These activities contribute heavily to CO2 emissions, deteriorating air and water quality, harming ecosystems, and endangering human health. For instance, cement production and fossil fuel processing are major sources of global carbon emissions (Le et al., 2023).

Natural sinks like forests and oceans absorb nearly half of CO2 emissions, playing a crucial role in climate stabilisation. However, if emissions increase, these sinks risk becoming overwhelmed, exacerbating climate change. This could lead to more extreme weather events, rising sea levels, and disrupted agricultural systems. The global push for decarbonisation and renewable energy, emphasised by the Paris Agreement, highlights the need to reduce emissions to prevent severe climate impacts (Rickels et al., 2024). The relationship between FDI and the environment is particularly relevant in regions like the Middle East and North Africa (MENA) and East Asia. In the MENA region, FDI in resource-intensive industries raises sustainability concerns. Climate change exacerbates issues like heat waves and water scarcity, making it imperative to balance economic and environmental priorities. Similarly, East Asia's rapidly growing economies face challenges related to energy demands and environmental impacts (Demena & Afesorgbor, 2020). Understanding FDI's impact on CO2 emissions from 1990 to 2020 in these regions is essential for policymakers seeking sustainable investment practices.

This study contributes to the literature on FDI and its environmental implications by examining its dual role in MENA countries from 1990 to 2020. The analysis investigates whether FDI exacerbates environmental degradation or facilitates cleaner technologies, using P-ARDL to explore short- and long-run effects on CO2 emissions. The findings reveal a sustained positive correlation between GDP growth, population growth, energy consumption, and FDI with CO2 emissions, suggesting that economic expansion and energy demands drive emissions. However, trade openness is shown to mitigate emissions, indicating that liberalised trade can offer environmental benefits. The study provides

DOI: 10.34659/eis.2024.91.4.972

actionable insights for policymakers. It emphasises the importance of restricting FDI in pollution-intensive industries and promoting clean technology adoption to minimise environmental damage. By focusing on sustainable investment strategies, developing economies can address environmental challenges while fostering growth. This research highlights the critical need for regional perspectives, especially in developing economies experiencing rapid growth and environmental pressures.

The paper is structured into key sections. Section 1 outlines the importance of studying FDI and CO2 emissions in the MENA region. Section 2 reviews relevant literature, while Section 3 explains the methodology. Section 4 presents empirical findings, and Section 5 concludes with key insights, policy recommendations, and future research directions regarding FDI's environmental impacts.

Literature Review

Foreign direct investment has a significant effect on both the environmental and economic frameworks of developing countries in terms of carbon dioxide (CO2) emissions. The interface between these two factors is quite complex and is influenced by variables such as governance structures, industrial methodologies, globalisation, economic expansion, and regulations of the region. Research indicates the relationship between FDI, Trade Openness and CO2 emissions, as FDI generally tends to increase industrial development, leading to higher energy consumption and rising emissions.

The pollution haven hypothesis posits that large firms relocate to countries with lenient environmental regulations, hence high CO2 emissions. In order to attract foreign investment, developing countries, particularly in Africa, tend to relax their environmental laws to create safe havens for polluting industries (Gharnit et al., 2020). In China, FDI-driven growth has led to a surge in CO2 emissions, as rapid economic development encourages energy-intensive activities (Cai et al., 2021). FDI in resource-abundant countries tends to concentrate in energy-intensive sectors such as oil and gas, which have high greenhouse gas emissions. This can be seen in the MENA region, where FDI in the oil sector has increased CO2 emissions (Bakhsh et al., 2021). The impact of FDI on CO2 emissions depends on the region and the level of the economy's development. Some regions use cleaner technologies, while others have higher emissions. In BRICS countries – Brazil, Russia, India, China, and South Africa – FDI has supported investments in renewable energy and greener technologies, resulting in lower emissions. This trend defies the pollution haven hypothesis, according to Rauf et al. (2023).

Economic Growth and Energy Efficiency: There is a tendency for economic growth to drive up energy use and emissions. Investment from FDI may encourage cleaner technology investments, thus making economic activities less carbon-intensive in countries that emphasise energy efficiency, as explained by Omri et al. (2014). Globalisation and FDI: Both these factors have significant implications with regard to CO2 emissions in the developing countries of the world. Such FDI would either transfer advanced technologies but, on the other hand, would further include some environmentally harmful practices. Energy-Intensive Industries: FDI tends to be attracted to energy-sucking industries, which will lead to increased CO2 emissions. The same is true for countries where the heaviest flows of FDI go to traditional, fossil-fuel-based sectors (Du et al., 2018). Technology Transfer and Sustainability: Within the FDI concept, sustainability can be possible through technology transfers. Most investments by countries with higher-than-average environmental laws have energy-efficient technologies in the home country, which are thus brought into host countries. When done with good governance, emissions are significantly reduced. Trade Liberalization: The associated increase in industrial production can induce higher emissions due to trade liberalisation linked to FDI. However, it also provides an opportunity for developing countries to access cleaner technologies and to step up the standards in which they are operating environmentally (Wang & Huang, 2022).

The globalisation factor, industrial practice, governance, and regional policy shape the relationship between FDI and emissions of CO2 among emerging economies. FDI increases emissions through growth and energy consumption, but it can also facilitate the adoption of cleaner technologies and sustainable practices. Effective governance and policy interventions are necessary to ensure that FDI bolsters development in a sustainable manner and not against the environment.

DOI: 10.34659/eis.2024.91.4.972

Data and Methodology

Data

This paper investigates the link between trade openness, FDI and CO2 emissions in MENA countries from 1990 to 2022. CO2 emissions, sourced from the environmental and WDI databases, serve as the dependent variable. FDI, measured through net inflows, is derived from WDI and UNCTAD data. Control variables, including GDP per capita, population growth, and electricity consumption, are drawn from international databases. Table 1 summarises the data, providing insights into the environmental impacts of FDI in the region.

Table 1. Definition of Variables

Symbol	Variable Name	Definition of Variables
LnCO2	Carbon dioxide emissions	Sector-specific CO2 emissions as a share of total fuel use.
LnFDI	FDI	Net inflows of FDI.
LnOPPEN	Trade openness	Trade openness measures a nation's international trade integration.
LnGDP	GDP	Gross Domestic Product in constant 2015 US dollars.
LnPOP	Population	Populations, total.
LnELC	Electricity	Per capita electricity consumption in kilowatt-hours (kWh).

Methodology

Pesaran et al. (1999) describe estimating the Panel ARDL model using PMG and MG estimators. Preliminary analysis checks slope homogeneity (SH) and cross-section dependence (CSD). Stationarity is tested with IPS or CIPS tests. Cointegration is verified using Pedroni and ECM tests. The Hausman test selects the appropriate estimator (Hausman, 1978). Error correction ensures equilibrium adjustment.

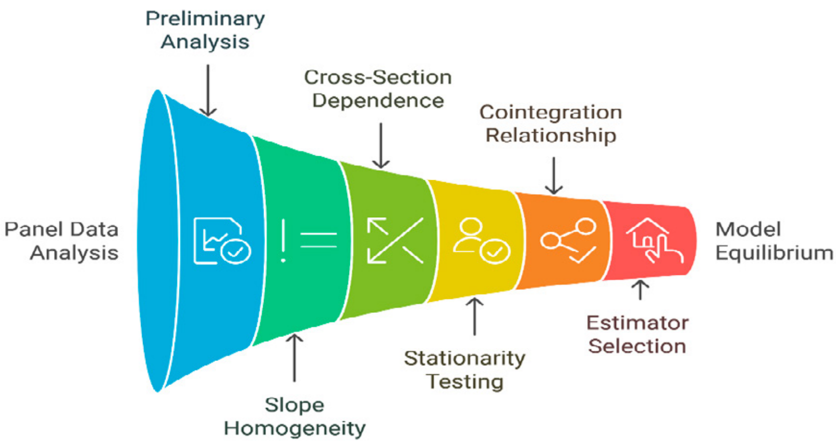

Figure 1. Empirical methodology

Model

The independent variables are based on the findings of the investigation that are rooted in previous studies of known authors such as (Demena & Afesorgbor, 2020; Cai et al., 2021) and are used to analyse the cause-and-effect relationship in terms of trade openness, FDI and CO2 emissions in 14 MENA nations, incorporating various variables across countries, some with incomplete data., outliers, or varied units of measurement. As a result of the processing, a panel dataset was built for the

DOI: 10.34659/eis.2024.91.4.972

analysis. The model used in the study is the ARDL model- the Dependent Variable, CO2 Emissions, lagged over periods (p), and the independent variables lagged over periods (q). The equation can be presented as follows:

$$y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \ldots + \varepsilon_{it}, \tag{1}$$

where:
y_{it} – is the dependent variable (CO2 emissions),
X_(i,t-j) – represents explanatory variables,
φ_i – accounts for fixed effects.

From this, an Error Correction Model (ECM) is derived:

$$\Delta LnCO2_{\mathrm{it}} = \theta_i \left[LnCO2_{i,t-1} - \theta_i'(LnFDI_{it} + LnGDP_{it} + LnOPEN_{it} + LnELC_{it} + LnPOP_{it}) \right] + \sum_{j=1}^{p-1} \xi_{ij} \, \Delta LnCO2_{\mathrm{it}} + \sum_{j=0}^{q_1-1} \beta'_{1j} \, \Delta LnFDI_{it} + \sum_{j=0}^{q_2-1} \beta'_{2j} \, \Delta LnGDP_{it} + \sum_{j=0}^{q_3-1} \beta'_{3j} \, \Delta LnOPEN_{it} + \sum_{j=0}^{q_4-1} \beta'_{4j} \, \Delta LnELC_{it} + \sum_{j=0}^{q_5-1} \beta'_{5j} \, \Delta \, LnPOP_{it} + \varphi_i + e_{it}. \tag{2}$$

where:
LnCO2 – Logarithm CO2 emissions,
LnFDI **–** Logarithm FDI,
LnGDP **–** Logarithm GDP,
LnOPEN **–** Logarithm of trade openness,
LnELC **–** Logarithm Electricity consumption per capita,
LnPOP **–** Logarithm Population.

Finally, the model is expressed in logarithmic form to estimate the relationship between the variables over time.

Summary Statistics

CO2 emission standard deviations among countries (9.93) are much higher than annual variations (12.56), which indicates that there is more fluctuation among nations. At the same time, FDI has a higher standard deviation within countries than between years, which results in more volatility in the annual FDI flows. Withal, the real GDP exhibits a greater annual variation than its between-country variation. The populous growth rate is the only one that shows a lower variation among countries and a higher variation within years. Trade openness and energy consumption per capita exhibit greater cross-country variation than annual variation.

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Table 2. Statistical data

Variable	Min	Max	Std.dev	Mean
LnCO2	0.32	51.32	12.56	9.93
LnFDI	-0.26	12.32	31.12	12.56
LnGDP	0.17	17.98	28.82	8.45
LnELC	0.25	8.86	17.43	14.23
LnOPEN	0.45	15.14	35.92	10.02
LnPOP	1.62	11.25	26.05	13.23

Matrix of Correlation

Using the correlation matrix, the economic and demographic indicators are found to be linked to weakly positive relationships between CO2 emissions and the various countries of the MENA region, such as trade openness, FDI and size of the market. This denotes that CO2 emissions generally go up when the quantities of these factors are increased, which means the relation is not extremely strong. Other factors or intermittent economic activities may be the reasons why these elements are not the main contributors to CO2 emissions in this context.

Table 3. Matrix of Correlation

Symbol	LnCO2	LnOPEN	LnFDI	LnGDPPC	LnELC	LnPOP
LnCO2	1					
LnOPEN	0.267	1				
LnFDI	0.150	-0.08	1			
LnGDP	0.307	-0.86	0.19	1		
LnELC	0.629	0.24	0.17	0.34	1	
LnPOP	0.334	0.41	0.01	0.82	0.32	1

As revealed by Table 3, the increase in FDI is usually inclined towards the manufacturing or services sector, in which environmental impacts are bound to be different and, at times, lead to lower CO2 emissions. Likewise, trade openness does not always go together with carbon intensity, especially when countries are exporting low-carbon goods. The good news is that, although there is some correlation with population growth, changes in energy efficiency and consumption patterns may underlie this relationship. Secondly, CO2 emissions are strongly positively related to per capita electricity consumption, reflecting the fossil fuel basis of most power generation and a pressing need for cleaner, more efficient energy use.

Empirical Results

Interdependence Across Sections

To calculate Equation (2), we initialise WWV between the Cross-Sectional Dependency Tests, which include the CD and LM Test (Pesaran, 2004) and B-P LM Test (Breusch & Pagan, 1980), sequentially. These tests clear up the interrelation between the countries under study. The recognition of the existence of cross-sectional dependence is very important to evade biased estimates. The graph shows the findings of the tests in Table 4.

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Table 4. Dependence of Cross-Sectional

Symbols	LnCO2	LnFDI	LnGDP	LnELC	LnOPEN	LnPOP
B-P LM	107.05*	25.12*	230.25*	165.96**	46.85**	82.83***
P-S LM	70.13**	9.95	18.95**	11.27**	29.35**	21.64**
P-CD	12.23**	5.07**	38.26**	43.32**	23.77**	23.21**

The data clearly outline that the null hypothesis of no cross-sectional dependency is disregarded, thus supporting cross-sectional dependence. That being said, then the next step would be testing the series for stationarity. We used Pesaran's (2007) CIPS and the Cross-sectionally Augmented Dickey-Fuller (CADF) Test for the application of the second-generation Panel Unit Root Test. Viewing the h- and t-statistics, with p-values found below 5%, shows that the composites reject the null hypothesis of a unit root (non-stationarity). The results of the test are tabulated below.

Testing for Stationarity in Panel Data

Panel Unit Root Tests were analysed to see if the panel data is stationary and imply that they do not are non-stationary in time series variables across cross-sections. Some of the test results indicate that variables are stationary at the first order of DGC while the rest need differencing to make the series stationary of order 1. The dataset looks like it consists of mixed ones with variables: some are at level, and some are at first different. In this case, Pesaran et al. (1999) have shown the great feasibility of the Panel Autoregressive Distributed Lag model (PANEL ARDL) approach. Specifically, it allows for the differentiation of different orders of integration and, therefore, a total exploration of the overall and specific relationships that are both long and short-term.

Table 5. Tests of Panel Unit Root

		LnCO2	LnFDI	LnOPEN	LnELC	LnGDP	LnPOP
CADF	At level	-3.21	-3.44	-3.01	-2.45	-4.33	-3.53
	At first différent	-2.14***	-2.71***	-3.33	-3.48***	-4.13***	-4.56***
CIPS	At level	-2.95	-3.67***	-4.74	-2.86	-3.41	-4.53***
	At first différent	-4.09***	-4.85***	-3.45***	-3.09***	-3.73***	-4.48***

Cointegration test results

The co-integration test results indicate a long-run equilibrium relationship, which is viewed to exist when changes in one variable are systematically related to changes in others.

Table 6. Test of Cointegration

	Stastics	P-V
Pedroni test	-1,52	0,06
Kao test	-6,91	0,003
Johansen Fisher Panel Cointegration Test		
None	365.3	0.01
At most 1	162.4	0.02
At most 2	64.79	0.01
At most 3	31.17	0.30
At most 4	23.88	0.68
At most 5	43.41	0.03

DOI: 10.34659/eis.2024.91.4.972

This confirms the presence of a stable long-run relationship in the panel data analysis. Checks for co-integration before estimating the PANEL ARDL model suggest there is a common stochastic trend. The commonly used tests of Kao and Pedroni can be applied in this context (Kao, 1999; Pedroni, 1999). The alternative hypothesis is that of cointegration, and the null of no cointegration. Test results are shown in Table 6.

PMG and MG-ARDL parameter estimates

First, the estimates from MG and PMG ARDL captured the short-run and long-run dynamics of variables. The MG estimator focuses on cross-sectional differences, whereas the PMG estimator brings out the common long-run effects. The cointegration test results using Pedroni, Kao, and Fisher Johansen test statistics reject the null hypothesis of no cointegration for all statistics with p-values below 5%. This confirms the presence of a long-run cointegrating relationship among the variables and thus allows the estimation of both short- and long-run correlations between FDI flows and CO2 emissions. The results obtained using the PMG, MG, and DFE estimators are presented in Table 7.

Table 7. Estimation parameter of PMG and MG-ARDL

Time-Run	Symbols	PMG		MG	
		Coef	P-V	Coef	P-V
Long-Run	LnFDI	0.01**	0.014	0.03**	0.027
	LnOPEN	-0.05***	0.002	0.15	0.245
	LnELC	0.36**	0.005	0.86***	0.001
	LnGDP	0.15***	0.001	-0.46*	0.051
	LnPOP	0.07***	0.003	-0.08	0.489
Short-Run	ECT(-1)	-0.23**	0.022	-0.60***	0.002
	Δ LnFDI	-0.001	0.306	-0.01**	0.028
	Δ LnOPEN	0.01	0.854	0.001	0.908
	Δ LnELC	0.23***	0.041	-0.16	0.239
	Δ LnGDP	0.24**	0.039	0.51***	0.001
	Δ LnPOP	0.05	0.162	0.09	0.284
	C	-0.689***	0.002	4.70*	0.051

First, an appropriate model should be selected, which is either PMG, MG, or DFE, before estimating the short- and long-run results. The Hausman Test is considered for this. A comparison of PMG and MG models gives a p-value of 0.51, which implies that the null hypothesis cannot be rejected, and hence, PMG is preferred because of its efficiency. The p-value between PMG and DFE was 0.99. This supports the null hypothesis, suggesting that a PMG ARDL model is advisable.

Discussion

This section presents results on the nexus of FDI flows, CO2 emissions, and other related variables in MENA based on analysis. In the long run, all parameters are significant at 5 percent levels of significance, while in the short run, some coefficients are not. The error correction term is negative and significant at the 1% level, indicating the existence of an error correction mechanism. Approximately 23% of the short-run deviations from equilibrium are corrected within (4 years, 4 months, and 15 days). The positive long-run relationship between FDI and CO2 emissions has been shown in the analysis. It explains that with a 1% rise in FDI, there was an increase of 0.01% in emissions, reflecting the venture into heavy industrial sectors which are intensive in green gases, such as coal, oil, and gas. These results are supported by (Sreenu, 2024; Boateng et al., 2024; Yu et al., 2024), which also show that energy-intensive industries result in high GHG emissions. Conversely, Demena and

DOI: 10.34659/eis.2024.91.4.972

Afesorgbor (2020) challenge this outcome, emphasising that some regions use FDI to adopt greener technologies and reduce emissions.

The growth in GDP also shows a positive relation in the case of emissions. A 1% increase in GDP increases CO2 emissions by 0.15%, which also meets economic theory relating energy consumption with economic growth. These results are consistent with observations made by Omri et al. (2014) for emerging economies. In that regard, the highest influence of electricity consumption per capita, where a 1% increase in it causes an increase in emissions by 0.36% due to dependence on fossil fuels to generate the same. Navarro et al. (2023) reinforce this relationship when arguing that reforms in the energy sector would be necessary for emissions reduction. The population contributes to emissions, as a 1% change in population CO2 change by 0.07% through industrial and transportation activity. This is in line with the findings of Pickson et al, (2024). However, trade openness inversely relates to emissions. A 1% increase reduces CO2 emission by 0.05%, which indicates that countries with higher trade openness are likely to have clean technology and more stringent environmental regulations. These findings are in agreement with Wang and Huang (2022) but contrast with the results obtained by Onwachukwu et al. (2021), who observed that trade liberalisation enhanced emissions in some developing countries. In the short run, both GDP and per capita electricity use are seen to significantly influence emissions.

While GDP and electricity consumption increase by 1%, their respective increase in emissions goes up to 0.24% and 0.23%. These short-run dynamics underline the immediate environmental impacts of economic and energy activities. Other related studies, such as Özbuğday and Erbas (2015), give credence to these findings by affirming the role of energy efficiency measures in mitigating short-run emissions. Results show a linkage of economic activities to environmental results. While FDI and economic growth drive emissions, trade openness and policy interventions offer a pathway toward sustainability. Policymakers should use such insight to advance sustainable development and decrease the negative impacts of climate change.

Conclusions And Policy Implications

This paper analysed the FDI-CO2 emissions nexus over three decades for East Asia and MENA panel countries, with the use of the Panel Autoregressive Distributed Lag model, which estimates both the short- and long-run influences of FDI, economic growth, energy consumption, population growth, and trade openness on environmental performances. The study investigated whether FDI inflows worsen environmental degradation or inspire green practices in these fast-growing yet environmentally constrained regions. A description of the key variables was done to ensure the accuracy and reliability of data on which to draw conclusions. Cross-sectional dependence tests and second-generation unit root tests accounted for shared economic and environmental characteristics among countries in the sample. The results showed the existence of a heterogeneous integration order among the variables, hence justifying the application of the PANEL ARDL model in order to effectively capture the short- and long-term dynamics. Cointegration tests revealed the existence of a stable long-term relationship between FDI, GDP, energy use, population growth, trade openness, and CO2 emissions, hence providing critical insights into how these factors interact and influence environmental outcomes over time.

Key findings indicated significant correlations. FDI inflows positively correlated with CO2 emissions, with a 1% increase in FDI leading to a 2% rise in emissions, suggesting that FDI exacerbates environmental degradation in pollution-intensive sectors. GDP growth also contributed to higher emissions, where a 1% increase in GDP resulted in a 0.15% rise in CO2 emissions, largely due to increased energy demand. Similarly, energy consumption showed a 1% increase, leading to a 0.36% rise in emissions, reflecting the region's reliance on fossil fuels. Population growth correlated with a 0.08% increase in emissions for every 1% rise, driven by escalating energy and industrial needs. In contrast, trade openness was linked to a 0.05% reduction in CO2 emissions per 1% increase, indicating that open trade can drive the adoption of cleaner technologies and efficient practices, potentially influenced by stricter environmental standards in trade agreements.

DOI: 10.34659/eis.2024.91.4.972

Policy implications highlight the need for governments to encourage "green FDI" by offering tax incentives and subsidies for sustainable investments. Stricter environmental regulations, such as carbon taxes and emission caps, are critical. Policies to boost energy efficiency – including renewable energy investments and promoting energy-saving technologies – could further reduce emissions. Trade liberalisation's role in lowering emissions underscores the importance of incorporating sustainability clauses in international trade agreements. Managing urbanisation and population growth is equally vital, with investments in sustainable urban planning, energy-efficient infrastructure, and environmental education mitigating population-driven environmental impacts.

The study faced limitations. Data variability across countries could affect result accuracy. Aggregating FDI without sectoral distinctions overlooked differing pollution levels between industries. Future research should focus on sector-specific analyses and broader environmental indicators like deforestation or water pollution. Endogeneity concerns in the FDI-CO2 link warrant alternate methodologies to strengthen causal inference. Additionally, the model's scope may not fully capture delayed effects or feedback loops between FDI and emissions.

This research underlines the complex relationship between FDI and CO2 emissions and thus is able to underline the need for policies balancing economic growth and environmental sustainability. Future research should focus on sectoral analysis, incorporating multiple environmental indicators and methodological limitations to better align the economic advantages of FDI with sustainable development goals.

Acknowledgement

The authors extend their appreciation to the Deanship of Scientific Research at Northern Border University, Arar, KSA for funding this research work through the project number "NBU-FFR-2025-2576-01".

The contribution of the authors

Conceptual framework development, N.M., B.L and S.R.; the comprehensive review of pertinent literature, S.R. and B.L.; the methodological approach, N.M.; formal analytical procedures, B.L. and S.R.; the writing of the manuscript, N.M., B.L and S.R.; the conclusions and discussion, N.M. and S.R.

The authors have perused and consented to the final published iteration of the manuscript.

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