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# Economic and Sustainability: The Moderating Role of Government Quality on Environmental Deterioration in E7 Countries

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## Abstract
This study aims to analyze the balance between economic growth and environmental sustainability by considering the moderating role of government quality in Emerging Seven (E7) countries using a quantitative methodology utilizing panel data from 2015 to 2024, along with the Generalized Method of Moments (GMM) and Moderated Regression Analysis (MRA) to examine the causal relationships between variables. The findings indicate that economic growth and population metrics have a positive impact on carbon emission escalation, while trade openness does not appear to have a statistically significant effect. In contrast, Foreign Direct Investment (FDI) initially presents a negative effect on carbon emissions, which shifts to a positive correlation in the context of declining government quality. This demonstrates that good governance can strengthen efforts to control carbon emissions and promote sustainable development. Thus, institutional capacity building and robust environmental policies are key to balancing economic growth and environmental preservation in E7 countries.
**Keywords:** emerging seven (E7), generalized method of moments (gmm), moderated regression analysis (mra), foreign direct investment (fdi), carbon emissions

## Introduction

The degradation of the environment constitutes an additional source of carbon dioxide. Human activities, persistent deforestation, and the escalating industrialization of the manufacturing sector adversely affect environmental quality. Consequently, to foster heightened environmental awareness, both the government and the people must focus on environmental degradation (Birgitta Sekar Winda 2023). The climate issues faced by seven developing nations, referred to as the E7 (Emerging 7), may impede sustainable economic advancement. (Dira dkk. 2023), assert that due to the complex interaction between ecological conditions and economic development, the environment has a crucial role within the economic framework. The *Environmental Kuznets Curve* (EKC) serves as a relevant tool within multiple frameworks to analyze the relationship between economic development and environmental quality (Farah dan Nugroho 2024). The research by Wafi Dinilhaq (2024), illustrates a sustained correlation between economic growth and environmental quality over prolonged durations, indicating that economic activities might cause ecological harm.

Studies by Bergougui dkk. (2024), Tu, Feng, dan Zhao (2022), and Fernández Fernández, Casquet Cano, dan Quiroga (2024) demonstrated a correlation between economic growth and global warming. The absence of stringent and systematically structured governmental controls has resulted in persistent rises in carbon emissions. Therefore, additional research is essential to comprehend the influence of governmental acts on carbon emissions. This study identifies population as the principal indicator, as population growth may lead to increased carbon emissions unless accompanied by the use of environmental technologies (Rafif, Sumarjiyanto, dan Maria 2024). Rokhmawati, Sarasi, dan Tawila (2024), indicates that governance quality greatly contributes to carbon emission reductions by transitioning energy structures to renewable sources and enhancing governance within the manufacturing sector. Consistent with the findings of Mahjabeen dkk. (2020), rigorous government regulations can substantially diminish escalating carbon emissions by improving environmental quality and fostering economic growth, with the government being instrumental in ensuring efficient resource allocation and attracting foreign investment. Research by (Liang dkk. 2024) demonstrates that economic dynamics significantly contribute to environmental degradation in emerging nations, highlighting the necessity of switching to renewable energy sources and the essential role of state policy in mitigating environmental damage. This underscores the essential importance of governmental dedication to environmental issues, necessitating attention.

The *Pollution Haven Hypothesis* (PHH) to clarify the nexus between Foreign Direct Investment (FDI) and environmental degradation. Studies by

Mert dan Caglar (2020) and Chiriluș dan Costea (2023) illustrate that foreign direct investment substantially exacerbates environmental degradation and shapes a nation's strategic pursuits to enhance economic growth. PHH, which posits that FDI is crucial as countries with lenient production intensification often absorb pollutants from nations with more stringent environmental regulations (Mert dan Caglar 2020). According to the findings of Chiriluș dan Costea (2023), the PHH theory suggests that firms can curtail expenses by relocating production from developed areas with rigorous governmental oversight to developing areas with more relaxed regulations, as the costs associated with environmental standards are higher. The effectiveness of governance can also affect how much green investment and environmental regulations can mitigate damage. Effective quality of governance generally enhances the efficacy of environmental policies and renewable energy initiatives, whereas a government with constrained capabilities will encounter challenges in addressing environmental degradation (Sheng, Meng, dan Akbar 2023).

Trade openness can increase carbon dioxide (CO2) emissions, which can indirectly affect economic growth (Ebrahim dkk. 2025). The environmental implications of trade openness can be examined through three principal effects. Regarding scale and technical effects, trade openness enhances the demand for a cleaner environment, prompting governments to establish stringent regulations on environmentally sustainable production standards. Conversely, the composition effect presents a theory that connects trade openness and carbon emissions known as the FEH (*Factor Endowment Hypothesis*), which suggests that trade openness will lead to increased pollution in developed nations while decreasing emissions in developing ones (Antweiler, Copeland, dan Taylor 2001), and (Korves, Martinez-Zarzoso, dan Monika 2011). Some study indicates that trade openness helps to the reduction of CO2 emissions, while others believe that this occurs because carbon emissions might worsen environmental quality. For instance, Ali, Law, dan Zannah (2016) and Zhang dkk. (2017) asserted in their investigations that trade openness adversely impacts carbon emissions in developed countries. This poses significant environmental threats to developing countries, potentially leading to heightened carbon emissions. Similarly, research by Yu dkk. (2019); Du, Li, dan Yan (2019); Bagadeem dkk. (2024) and Carlos dan Lorente (2020) elaborated on the notion that to diminish greenhouse gases in highly industrialized nations, free trade plays a crucial role with recyclable industrial products, promoting exports in technology-intensive industries, and enforcing more rigorous environmental regulations.

The researchers sought to explore the determinants of environmental degradation contributing to ecological decline in the *Emerging7* economies, encompassing China, India, Brazil, Russia, Indonesia, Mexico, and Turkey. The E7 countries rank among the highest per capita CO2 emitters globally. Notably, three of these seven countries are included in the list of the top five contributors to CO2 emissions per capita worldwide (Liang dkk. 2024). Consequently, the E7 countries present a pertinent area of study, particularly concerning the environmental harm associated with rising CO2 levels. This study is predicted to greatly improve understanding of the elements contributing to environmental deterioration, and this analysis can serve as a feasible foundation for government agencies and politicians in resolving issues linked to environmental harm.

## Methods

This study is a descriptive quantitative analysis using an explanatory approach, with the aim of explaining data models while clarifying the causal relationships and impacts among variables. *Stata-14* was utilized for the analysis of panel data from E7 nations spanning the years 2015 to 2024. The variable being examined is environmental damage, acting as a representation for $CO_2$ emissions per capita. Governance quality serves as the moderating variable, while the independent variables trade openness, FDI, economic growth, and population. The data sources include the *Indicators of World Development* (WDI), *World Integrated Trade Solutions* (WITS), and *Worldwide Governance Indicators* (WGI). The *Generalised Method of Moments* (GMM) was utilized to scrutinize the panel data model. This approach was selected to utilize the lag of the dependent variable, avoiding potential endogeneity and autocorrelation issues. Baltagi (2005) argues that dynamic panel data regression is a methodological framework that integrates a lag dependent variable within the formulation of the independent variables. In that way, when a dynamic panel data model employs ordinary least squares estimation, the resulting estimates are biased and inconsistent. Lags in dependent variables further indicate a correlation between error terms and each of the independent variables. Variables that exhibit temporal variability and are influenced by other variables can be characterised as dynamic (Arellano dan Bond 1991). Blundell dan Bond (1998) explained that estimation results derived from GMM are characterised by unbiasedness, consistency, and efficiency in parameter estimation. As an additional analysis, *Moderated Regression Analysis* (MRA) was used to explicitly examine the moderating effect and to calculate marginal effects on panel data. The main steps in testing MRA as a moderator variable are: a) Mean-center variables X and Z before creating interaction variables, b) Calculate the interaction coefficient and T-test, c) Calculate the marginal effect of X at a specific level of Z (Memon dkk. 2019).

**Result and Discussion**

Generalised Method of Moments (GMM) Test

Simultaneous Test (F Test)

Table 1.
F-test results

| | | |
|---|---|---|
| Wald chi2(4) | = | 15.64 |
| Prob > chi2 | = | 0.0035 |

Source: STATA 14 (processed), 2025

H0 was rejected in favor of H1, based on the F-test, which yielded a *p-value* of 0.0035 < α (0.05), indicating significance. This indicates that the entire set of independent variables has a simultaneous impact on the dependent variable.

Partial (Sargan Test)

Table 2.
partial-test result

```
. estat sargan
Sargan test of overidentifying restrictions
        H0: overidentifying restrictions are valid

        chi2(32)      =  27.98271
        Prob > chi2   =    0.6702
```

Source: STATA 14 (processed), 2025

The sargan test results showed a *chi-square* value of 27.98271 and a *p-value* of 0.6702, which exceeds α (0.05). These findings are robust enough to support further investigation.

Consistency testing

Table 3.
Consistency testing result

```
. estat abond

Arellano-Bond test for zero autocorrelation in first-differenced errors

  Order      z      Prob > z
    1     1.8481   0.0646
    2    -1.3027   0.1927

  H0: no autocorrelation
```

Source: STATA 14 (processed), 2025

Table 3 results show that the second-order *z-value* is -1.3027, with *p > chi2* = 0.1927 > α (0.05). As a result, H0 is consistent with the model.

Impartiality Test

Table 4.
Impartiality test

| Variable | fdgmm | fem | cem |
|---|---|---|---|
| lY | 0.55894104 | -0.28086693 | 0.74404016*** |
| lX1 | -10.097853 | -7.0652359 | -0.11935764 |
| lX2 | 2.4476147 | 0.15978639 | 0.180992 |
| lX3 | 0.14073728 | -1.389e-14 | -0.01395571 |
| X4 | -1.288e-15 | -1.389e-14 | 2.787e-15 |
| _cons | 124.77103 | 65.234216 | -2.1478689 |
| N | 53 | 60 | 60 |

Source: STATA 14 (processed), 2025

The outcomes from analyzing table 4: 1) The partial test indicated that H0 was accepted, suggesting the model is appropriate for further examination; 2) The consistency test also accepted H0, confirming that the data was reliable; 3) In the impartiality test, the coefficient value of Endogenous Lag 1 in the FD-

GMM model exceeded that of Endogenous Lag 1 in the FEM model, leading to the conclusion that the model met the impartiality criterion.

First Difference Generalised Method of Moments Model Specification Test

Based on the information in table 5, with a significance level of α: 0.05: 1) The impact of X1 (Population, total) is measured at -10.09785, with a *p-value* of 0.003, signifying a substantial effect. This means that adding one unit, if it means growth in X1, will cause an increase in carbon emissions of 97.85%. 2) The influence of X2 (GDP constant 2015 US$) is assessed to be 2.447615, with a p-value of 0.002, showing a significant correlation. Consequently, each unit augmentation in X2 leads to a 44.76% rise at the carbon dioxide. 3) Effect of X3 (net inflows BoP, current US$) is logged at 0.1407373 with a p-value of 0.057, indicating insignificance. A one-unit rise in X3 will lead to a decline in carbon emissions. 4) The effect of X4 (current US$) is recorded as -1.29e-15 with a p-value of 0.905, indicating lack of significance. A one-unit increase in X4 will therefore reduce carbon emissions by 29%.

Table 5.
results of the AB-GMM test estimation

| lY | Coef. | Std. Err. | z | P>\|t\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| lY | 0.558941 | 0.6566624 | 0.85 | 0.395 | -0.7280936 | 1.845976 |
| lX1 | -10.09785 | 3.354087 | -3.01 | 0.003 | -16.67174 | -3.523963 |
| lX2 | 2.447615 | 0.7902474 | 3.10 | 0.002 | 0.8987582 | 3.996471 |
| lX3 | -1.29e-15 | 1.08e-14 | 1.90 | 0.057 | -0.0042174 | 0.2856919 |
| X4 | -1.29e-15 | 1.08e-14 | -0.12 | 0.905 | -2.25e-14 | 1.99e-14 |
| _cons | 6.082592 | 48.73517 | 2.56 | 0.010 | 29.25 186 | 220.2902 |

Source: STATA 14 (processed), 2025

The FD-GMM analysis above yields an *Endogenous Lag 1* coefficient for the dependent variable Y of 0.55894104. This value of the Endogenous Lag 1 coefficient in the *Fixed Effect Model* (FEM), which is -0.28086693, while remaining lower than the CEM, which is at 0.74404016. This observation indicates that there is no downward bias. Based on the explanation and the test outcomes detailed above, it is determined that the most suitable and effective model for this analysis is the GMM suggested by Arellano-Bond, as it satisfies the requirements for over-identification, consistency, and differentiation of endogenous variables. Therefore, in the Arellano-Bond model, estimating the long-term relationship is unnecessary since all variables in this study are represented in the form of first differences (Arellano–Bond ≠ long-term model).

Moderated Multiple Regression Analysis (MRA)

*Fixed Effects* (FE) test

This suggests that the findings for X3*Z indicate a positive and significant impact to decreased carbon emissions. The study's results corroborate that X3 is a contributing factor exerting pressure on carbon emissions, thus a 5% increase in X3 may elevate carbon emissions by 0.3%. Strategies such as improving governance quality, ensuring better policy coordination, or bolstering governance capacity can be effective in reducing the decline in Y caused by X3. This research indicates that the governance quality variable can moderator of the correlation between FDI and carbon emissions, proposing that enhanced governance quality can alleviate the detrimental impact of FDI on carbon emissions. Hence, at a certain threshold of Z, the influence of FDI diminishes.

| | Coefficients (b) fe | (B) re | (b-B) Difference | sqrt(diag(V_b-V_B)) S.E. |
|---|---|---|---|---|
| X1 | -1.44e-08 | -7.89e-09 | -6.47e-09 | 2.85e-08 |
| X2 | 6.98e-12 | 4.53e-13 | 6.53e-12 | 2.85e-12 |
| X3 | -1.11e-10 | -1.33e-10 | 2.22e-11 | 3.21e-11 |
| X4 | -2.15e-12 | 1.16e-12 | -3.31e-12 | 1.52e-12 |
| Z | -.034231 | -.1277893 | .0935583 | .0388016 |
| X1Z | 1.80e-10 | 1.10e-10 | 6.97e-11 | 1.20e-10 |
| X2Z | -1.00e-13 | -2.74e-16 | -9.98e-14 | 4.34e-14 |
| X3Z | 1.50e-12 | 1.97e-12 | -4.69e-13 | 4.78e-13 |
| X4Z | 3.14e-14 | -1.70e-14 | 4.84e-14 | 2.23e-14 |

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(1) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 5.81
Prob>chi2 = 0.0159
(V_b-V_B is not positive definite)

Source: STATA 14 (processed), 2025

This means that the moderation variable Z provides only weak evidence of moderation for FDI in the *Moderated Multiple Regression Analysis* (MRA) model specification. In accordance with the findings of (Van dkk. 2024) explained it was elucidated that in contexts where governmental systems are stringent, FDI will strengthen environmental regulations because it is difficult for the government to lobby investors to make investments. Conversely, when government political systems are weak, FDI will weaken environmental regulations because investors will find it easy to lobby the government.

Hausman test

The Hausman test resulted in a *chi-square* statistic of 5.81 and a *p-value* of 0.0159, prompting the rejection of the null hypothesis (H0). This outcome reveals a statistically significant difference between the coefficients of the *FE* and *RE*. Therefore, FE model is considered the most appropriate in terms for application in this study. The selection of the FE model implies that the specific characteristics of each country are unique and correlate with the independent variable, so that the FE model can provide more consistent and unbiased estimates than the RE model. This finding is in compliance with the recommendations Wooldridge (2016) related to the selection of panel models that consider unobserved heterogeneity and supported by the results of Pei dan Pei (2023) which found that the selection of FE models is more relevant in the case of cross-country environmental economic analysis.

Table 7.
Hausman test results

```
Fixed-effects (within) regression               Number of obs      =        70
Group variable: negara                          Number of groups   =         7

R-sq:                                           Obs per group:
     within  = 0.3473                                         min =        10
     between = 0.0035                                         avg =      10.0
     overall = 0.0225                                         max =        10

                                                F(9,54)            =      3.19
corr(u_i, Xb)  = -0.6909                        Prob > F           =    0.0036
```

| Y | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| X1 | -1.44e-08 | 2.88e-08 | -0.50 | 0.620 | -7.21e-08 | 4.34e-08 |
| X2 | 6.98e-12 | 4.02e-12 | 1.73 | 0.088 | -1.09e-12 | 1.50e-11 |
| X3 | -1.11e-10 | 4.03e-11 | -2.75 | 0.008 | -1.92e-10 | -3.02e-11 |
| X4 | -2.15e-12 | 1.93e-12 | -1.12 | 0.269 | -6.02e-12 | 1.71e-12 |
| Z | -.034231 | .0750323 | -0.46 | 0.650 | -.1846618 | .1161998 |
| X1Z | 1.80e-10 | 1.67e-10 | 1.08 | 0.286 | -1.54e-10 | 5.14e-10 |
| X2Z | -1.00e-13 | 6.00e-14 | -1.67 | 0.101 | -2.20e-13 | 2.03e-14 |
| X3Z | 1.50e-12 | 6.14e-13 | 2.44 | 0.018 | 2.66e-13 | 2.73e-12 |
| X4Z | 3.14e-14 | 2.82e-14 | 1.11 | 0.272 | -2.52e-14 | 8.80e-14 |
| _cons | 6.082592 | 11.66805 | 0.52 | 0.604 | -17.31044 | 29.47562 |
| sigma_u | 3.3221826 | | | | | |
| sigma_e | 1.7852147 | | | | | |
| rho | .77594092 | (fraction of variance due to u_i) | | | | |

F test that all u_i=0: F(6, 54) = 1.42    Prob > F = 0.2223

Source: STATA 14 (processed), 2025

Classic Assumption

Multicollinearity

A multicollinearity assessment was conducted to ascertain the presence of a significant linear correlation among the independent variables *within* the regression model. In this study, the evaluation was based on the uncentered *Variance Inflation Factor* (VIF). The outcomes:

Table 8.
Multicollinearity test results

| Variable | VIF | 1/VIF |
|---|---|---|
| X2 | 14.23 | 0.070 |
| X4 | 9.07 | 0.110 |
| X3 | 3.81 | 0.262 |
| X1 | 3.64 | 0.275 |
| **Mean VIF** | **7.69** | |

Source: STATA 14 (processed), 2025

The test results suggest that the regression model displays multicollinearity, primarily attributed to variable X2, which has a VIF value that surpasses the typical threshold (VIF > 10). This situation can impact the reliability of regression coefficient estimates and compromise the accuracy of interpreting the relationships between variables. Therefore, improvements must be made by implementing *mean-centring*:

Table 9.
Results of Multicollinearity Test Corrections

| Variable | VIF | 1/VIF |
|---|---|---|
| X4_c | 9.90 | 0.100 |
| X2 | 9.79 | 0.102 |
| X3 | 3.00 | 0.333 |
| X1 | 2.57 | 0.388 |
| **Mean VIF** | **6.32** | |

Source: STATA 14 (processed), 2025

According to the results from the multicollinearity evaluation using the uncentered *Variance Inflation Factor* (VIF), the VIF values ranged from 2.57 to 9.90, with a mean of 6.32. This implies that the regression model is largely free from multicollinearity, ensuring that the regression coefficient estimates are dependable.

Autocorrelation test
Table 10.
Autocorrelation test results
xtreg Y X1 X2 X3 X4, fe vce(country clusters)

| Y | Coef. | Robust Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| X1 | 5.63e-09 | 1.22e-09 | 4.63 | 0.004 | 2.65e-09 | 8.60e-09 |
| X2 | 7.50e-14 | 1.61e-13 | 0.47 | 0.658 | -3.19e-13 | 4.69e-13 |
| X3 | -8.89e-12 | 9.65e-12 | -0.92 | 0.392 | -3.25e-11 | 1.47e-11 |
| X4 | 3.52e-14 | 2.92e-14 | 1.21 | 0.273 | -3.62e-14 | 1.07e-13 |
| _cons | 1.02678 | .9098996 | 1.13 | 0.302 | -1.199664 | 3.253224 |
| sigma_u | 3.4815482 | | | | | |
| sigma_e | 2.0698774 | | | | | |
| rho | .73884525 | (fraction of variance due to u_i) | | | | |

xtscc Y X1 X2 X3 X4, fe

```
Regression with Driscoll-Kraay standard errors   Number of obs      =        70
Method: Fixed-effects regression                 Number of groups   =         7
Group variable (i): negara                       F(  4,       9)    =      2.04
maximum lag: 2                                   Prob > F           =    0.1720
                                                 within R-squared   =    0.0414
```

| Y | Coef. | Drisc/Kraay Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| X1 | 5.63e-09 | 3.94e-09 | 1.43 | 0.187 | -3.28e-09 | 1.45e-08 |
| X2 | 7.50e-14 | 1.93e-13 | 0.39 | 0.706 | -3.61e-13 | 5.11e-13 |
| X3 | -8.89e-12 | 5.07e-12 | -1.75 | 0.114 | -2.04e-11 | 2.59e-12 |
| X4 | 3.52e-14 | 2.25e-14 | 1.56 | 0.152 | -1.57e-14 | 8.62e-14 |
| _cons | 1.02678 | 1.350321 | 0.76 | 0.466 | -2.027859 | 4.081419 |

Source: STATA 14 (processed), 2025

Using the *FE* method for panel data regression analysis, along with adjustments for autocorrelation and heteroscedasticity through *Clustered Standard Errors* at the country level, the model demonstrates resilience against both autocorrelation and heteroscedasticity. Thus, the estimation results have fulfilled the model assumptions and can be declared valid for use in research, and the value for X1 indicates a significant effect. Statistically, these findings reveal that X1 is an important factor influencing Y. In other words, if the government wants to control Y, then intervention can be directed at managing variable X1. This indicates that an increase in X1 is associated with a rise in Y. These results confirm that X1 has important policy implications, as it has the potential to produce real changes in Y and can be considered as supporting variables that require additional approaches such as advanced modelling, the addition of control variables, or structural lag analysis to obtain more comprehensive results.

*Moderated Multiple Regression Analysis* (MRA) after interaction

Formulation of interactions for each variable for MRA

To reduce interpretation and multicollinearity issues, the recommended solution for panel data is mean-centring on the panel data variables for accurate interpretation. Interaction terms aim to make moderation hypotheses statistically testable (Memon dkk. 2019).

Table 11.
MRA interaction variables

```
foreach v in X1 X2 X3 X4 {
2.
    summarize `v', meanonly
3.
    gen c_`v' = `v' - r(mean)
4.
}

gen inter1 = c_X1*c_X4

gen inter2 = c_X2*c_X4

gen inter3 = c_X3*c_X4

gen inter4 = c_X4*c_X4
```

Source: STATA 14 (processed), 2025

Classic assumption test

Multikolineritas test

Table 12.
Multikolineritas test results

| Y | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| c_X1 | -3.87e-09 | 2.83e-09 | -1.37 | 0.176 | -9.52e-09 | 1.78e-09 |
| c_X2 | 1.39e-12 | 5.83e-13 | 2.38 | 0.020 | 2.23e-13 | 2.56e-12 |
| c_X3 | -4.54e-11 | 1.20e-11 | -3.80 | 0.000 | -6.93e-11 | -2.15e-11 |
| c_X4 | 2.28e-13 | 5.92e-13 | 0.38 | 0.702 | -9.56e-13 | 1.41e-12 |
| inter1 | -3.48e-22 | 6.95e-22 | -0.50 | 0.618 | -1.74e-21 | 1.04e-21 |
| inter2 | -3.56e-26 | 1.98e-26 | -1.80 | 0.077 | -7.51e-26 | 4.03e-27 |
| inter3 | 1.44e-24 | 4.85e-25 | 2.98 | 0.004 | 4.75e-25 | 2.41e-24 |
| inter4 | 4.61e-27 | 1.09e-26 | 0.42 | 0.674 | -1.72e-26 | 2.64e-26 |
| _cons | 5.508555 | 2.256345 | 2.44 | 0.018 | 0.9967145 | 10.0204 |

| **Variable** | **VIF** | **1/VIF** |
|---|---|---|
| z_X1 | 8.41 | 0.118910 |
| r_inter4 | 7.32 | 0.136673 |
| z_X3 | 3.95 | 0.252915 |
| r_zX2 | 3.02 | 0.331559 |
| r_inter3 | 2.78 | 0.359375 |
| r_inter2 | 1.97 | 0.506944 |
| r_inter1 | 1.85 | 0.540610 |
| **Mean VIF** | **4.19** | |

Source: STATA 14 (processed), 2025

According to the uncentered *Variance Inflation Factor* (VIF) results, the VIF values with an average of 6.32. This indicates that the model does'nt experience multicollinearity, so the regression coefficient estimates are reliable.

Autocorrelation test

The findings derived from the panel regression employing the Fixed Effects (FE) method suggest that the model demonstrates moderate explanatory power, reflected in a within *R-squared* value of 0.1226. In the preliminary phase, a test was performed with clustered standard errors at the country level to

mitigate potential heteroscedasticity and correlations within clusters. This analysis revealed that only the interaction variable inter4 led to the rejection of H0 and acceptance of H1, indicating a notable impact on the dependent variable, as evidenced by a *p-value* of 0.027. In contrast, other variables such as z_X1, z_X2, z_X3, and z_X4 did not exhibit a significant effect at the specified significance level. However, the clustered standard errors approach has limitations when the number of clusters is relatively small, such as 7 countries.
Table 13.
Autocorrelation test results

| Drisc/Kraay | | | | | | |
|---|---|---|---|---|---|---|
| Y | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. Interval] | |
| z_X1 | 3.169336 | 2.269449 | 1.40 | 0.196 | -1.964514 | 8.303185 |
| z_X2 | 0.3596937 | 0.9456312 | 0.38 | 0.712 | -1.779473 | 2.4988 |
| z_X3 | -0.6050263 | 0.3531241 | -1.71 | 0.121 | -1.403849 | 0.193796 |
| z_X4 | 0 .3579483 | 0.2342193 | 1.53 | 0.161 | -0.1718926 | 0.8877892 |
| _cons | 3.887467 | 0.3211151 | 12.11 | 0.000 | 3.161055 | 4.61388 |

Therefore, it is necessary to re-estimate using *Driscoll–Kraay* standard errors, which are more appropriate for addressing heteroscedasticity, autocorrelation, and cross sectional dependence among countries, as explained in (Moody 2016). On the other hand, the inter4 variable, which had been significant in the model with clustered standard errors, is rendered insignificant, indicating that its significance may have been influenced by variance bias resulting from cross-unit correlation and residual autocorrelation (Hoechle 2007).

Overall, these results confirmed that statistical inference in panel data is sensitive to the choice of standard error correction method. The use of the *Driscoll–Kraay* method strengthened the findings of this study by overcoming heteroscedasticity, autocorrelation, and cross-sectional dependence, which are prevalent characteristics of cross-country panel data. Thus, the estimation results were more stable and reliable than the clustered standard errors approach. These findings are in accordance with Driscoll dan Kraay (1998) researcher of this pape, who recommended the use of the *Driscoll–Kraay* correction in studies involving cross-country macro data.

## Conclusion

This study confirms that environmental degradation in the Emerging Seven (E7) countries is still significantly influenced by economic and demographic dynamics. The results of the analysis using GMM show that economic growth and population increase have a real contribution to the rise in carbon emissions. These findings are in line with the *Environmental Kuznets Curve*, which shows that in the early stages of growth, economic activity and industrialization still depend on energy-intensive and environmentally unfriendly resources. The trade openness variable does not show a significant effect on carbon emissions. This condition may reflect differences in environmental policies, trade structures, and technological capacities among E7 countries, which make this relationship inconclusive. In addition, FDI tends to have a negative impact on the environment when the quality of governance is low, but it can be a positive instrument for strengthening environmental standards when governance is stronger. These findings confirm the relevance of the *Pollution Haven* theory while opening up the possibility that the *Factor Endowment Hypothesis* (FEH) can occur when governance is improved. *Moderated Regression Analysis* (MRA) strengthens the evidence that governance quality acts as a moderating variable, although its influence is relatively weak. This means that governance has the capacity to mitigate the negative impact of FDI on the environment, but this influence is only optimal when accompanied by consistent regulation, transparency, and effective law enforcement.

Thus, this study confirms that efforts to maintain environmental sustainability in E7 countries depend not only on economic transformation, but also on improving the quality of institutions. Institutional capacity building, the formulation of environmentally friendly policies, and the strengthening of foreign investment regulations are strategic steps needed to balance the agenda of economic growth and environmental preservation.

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