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Empirical evaluation of the pollution haven hypothesis for seven largest emerging economies within the framework of the new global climate agreements

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ABSTRACT

This study aims to determine whether the Pollution Haven Hypothesis (PHavenH), which suggests the negative impact of the FDI on environmental quality (EQ), is valid in seven selected emerging market economies for the period 1990-2020. To achieve this goal, the CO2 emission (CE) model includes renewable energy consumption (REC) in addition to the FDI variable. The elasticity coefficients of the model, in which cross-sectional dependence (CSD) and slope heterogeneity were determined, were estimated by the Augmented Mean Group (AMG) method. The study found that FDI and REC positively influenced the EQ of the countries examined. The Dumitrescu-Hurlin (D-H) test results indicated a bidirectional causality relationship between FDI and CE. Additionally, a unidirectional causality was observed from REC to CE. These results suggest that both FDI and REC play a role in improving EQ. The results of the analysis show that the PHavenH, which expresses the view that FDI in the relevant countries causes environmental degradation (ED) in developing countries, is not valid. In other words, it confirms the Pollution Halo Hypothesis (PHaloH), which points to the finding that FDI improves EQ in the countries concerned. In this context, it has been concluded that REC has an important contribution to determining the validity of this hypothesis. The findings of the study suggest that it is essential to formulate policy recommendations aimed at boosting the production and utilization of renewable energy in the seven emerging market economies under investigation. Such initiatives can help enhance environmental sustainability and contribute to a cleaner and greener future for these countries.

I. Introduction

Within the framework of globalization, which refers to a process in which the transfer of capital, labor, and technology is free, as well as goods and services that have affected the world since the 1990s, countries have faced increasing competition (Zeibote et al., 2019). Adam Smith, who is considered the father of modern economics and whose competition is the basis of the capitalist system, mentioned in his book The Wealth of Nations written in 1776 that all countries would benefit through free trade and that countries should concentrate on what they can produce most appropriately (Chandra, 2004). International trade and FDI help in the formation of the global value chain by connecting all production processes from raw material extraction to manufacturing, design, R&D, and marketing. Therefore, a more efficient and competitive industrial structure is formed (Zhang, 2010). After the increasing production and trade in the global world, problems have started to be experienced in many areas.

The rapid increase in global air pollution and greenhouse gas emissions is having adverse effects on the climate. This situation has significant implications for environmental sustainability, ecosystem functionality, and societal well-being (Avcı et al., 2024). Energy is a crucial production factor in the process of economic development. However, growing concerns about global warming and climate change are exerting pressure to adopt an environmentally friendly approach to energy consumption. International initiatives highlight that the use of fossil fuels contributes to air pollution and greenhouse gas emissions, leading to environmental degradation. This situation can have adverse effects on the health and productivity of both current and future generations (Cetin and Yuksel, 2018). Therefore, it is critically important for global economies to develop innovative solutions to build a resilient and sustainable future in the face of environmental impacts, particularly with the rise of the Fourth Industrial Revolution. For example, policy measures aimed at renewable energy sources play a vital role in supporting sustainable development worldwide by reducing environmental pollution (Alvarado et al., 2022; Cetin et al., 2023a, 2024; Han et al., 2024).

In the face of many global challenges such as poverty, inequality, climate change, access to clean energy, and ED the world, the United Nations

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has set up Sustainable Development Goals (SDGs) to achieve a better and sustainable future for all. The interconnected 17 goals must be achieved by 2030 for a better world. Among these goals, climate change and ED caused by human activities threaten life on Earth, increase instability, and trigger global migrations if not urgently controlled. Since the first industrial revolution, new methods and inputs in production have increased production and welfare, but over time, excessive resource consumption and environmental pollution (EP) have started to create problems. In recent years, global issues like climate change, global warming, and EP have been integrated into the United Nations' SDGs, placing responsibilities on all countries. The Kyoto Protocol in 1997 (United Nations Climate Change) and the Paris Conference (UNFCCC) in 2015 are just a few of the agreements that aim to strengthen the worldwide effort to address the challenge of climate change to advance sustainable development. Protect the environment, and reduce all parties' greenhouse gas emissions. Therefore, the PHavenH, which is important for SDG and is based on the conclusion that FDI causes EP in developing countries, continues to be researched in the academic literature for different countries and periods. The validity of the PHaloH is confirmation of a win-win situation for developed and developing countries. On the other hand, the validity of PHavenH is a confirmation of a win-lose situation for developed and developing countries, while it points to a lose-lose situation for the whole world.

In this study, the PHavenH was tested using data from seven large emerging economies which are China, India, Brazil, Mexico, Turkey, South Africa, and Malaysia. Except for India, which is one of the countries with a low middle-income level, other countries are among the countries in the upper middle-income group. An emerging market economy refers to a country that wants to make investments that require large-scale financing to develop and industrialize rapidly. These countries need FDI in the development process and want to attract FDI to their countries by offering some advantages. Therefore, the validity of the PHavenH will be tested in these countries, which are in the process of becoming a developed economy. These countries are among the countries with both high growth rates and the highest CE in the world (Table 1).

Table 1: GDP growth (annual %) and CO2 emissions (kt)

	2000		2010		2022	2020
	GDP	CO2	GDP	CO2	GDP	CO2
Brazil	4,38	313670,8	7,52	397931,1	2,90	414138,8
China	8,49	3346525,8	10,63	8474922,7	2,98	10944686,2
India	3,84	937858,4	8,49	1659983	7,24	2200836,3
Malaysia	8,85	124355,9	7,42	199867	8,65	245139,3
Mexico	5,02	379176	4,97	462869,5	3,89	383131,4
South Africa	4,2	284463,3	3,03	425548,4	1,91	393241,6
Turkey	6,93	216396,5	8,42	297814	5,53	407406,2

Source: World Bank, World Development Indicators (WB-WDI).

Figure 1 shows the inflows of FDI to the countries included in the analysis over ten-year periods. Among these countries, FDI inflows to Malaysia, China, and Brazil are more common.

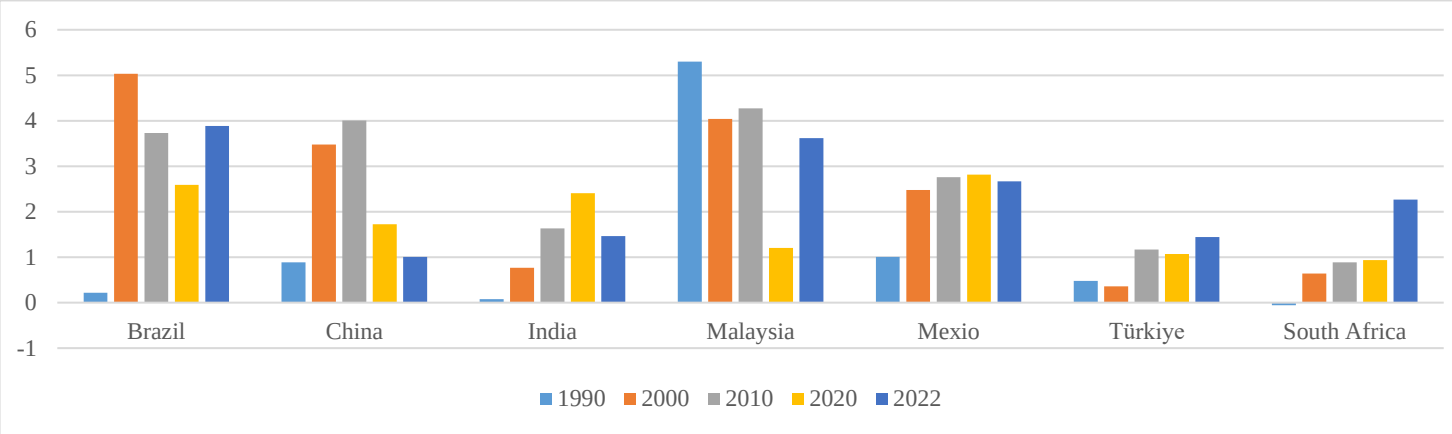

Figure 1: Foreign direct investment of Emerging Economies, net inflows (% of GDP)

Source: WB-WDI

The content of the study is as follows: First, the studies in the literature on this subject are included, and in the next section, the analysis results of the study and finally evaluation and policy recommendations are included.

2. Empirical Review of Literature

Countries that do not have sufficient technology, savings, and capital accumulation in the development process need foreign savings and technology. Although there is no clear conclusion on this issue in the literature (Goh et al., 2017), some empirical study results have established a positive relationship between FDI and economic growth (Sijabat, 2023; Ibhagui, 2020; Li and Liu, 2005). FDI has played an important role in the economic development of the ASEAN countries as a source of technological know-how and capital, especially in the 1990s (Diaconu, 2014).

Bashir et al. (2014) investigated the relationship between FDI and economic growth in their study of South Asian countries (Pakistan, India, Bangladesh, China, and Srilanka) and revealed the role of FDI in the rapid economic growth in China. Other countries, on the other hand, stated that if they develop their infrastructure, reduce their foreign debts, tax exemption, and create a stable political environment, they will accelerate their economic development like China by attracting FDI. For this reason, to attract FDI to their countries, they put forward more flexible practices, especially in terms of environmental regulations, to reduce costs. These countries, which provide incentives for foreign capital that wants to escape from environmental regulations in their own country and access cheap labor and natural resources, are referred to as pollution paradise or shelters.

The relationships between FDI and EP, often associated with CE, have been well-researched for different countries and different periods. Mixed evidence exists between FDI and carbon efficiency in the literature. We will review some of the existing literature summarizing the relationships between CE and FDI to explore the validity of the PHeavenH and PHaloH.

However, in recent years, global problems such as climate change and global warming, as well as EP, are included in the SDG of the United Nations and impose responsibilities on all countries. The Kyoto Protocol in 1997 (United Nations Climate Change) and the Paris Conference (UNFCCC) in 2015 are just a few of the agreements that aim to strengthen the global response to the threat of climate change to promote sustainable development, protect the environment, and reduce all parties greenhouse gas emissions. Therefore, the PHavenH, which is important for SDG and is based on the conclusion that FDI causes EP in developing countries, continues to be researched in the academic literature for different countries and periods.

Many previous studies have indicated a positive association between FDI inflows and EP (Ozkan et al., 2023) in China; Temurlenk and Logun (2022) in Turkey; Balsalobre-Lorente et al. (2022) in 5 EU countries; An et al. (2021) in 64 Belt the Road countries; Koksal and Cetin (2021) in Turkey. Shahbaz et al. (2019) found increased FDI to coincide with increased ED in the Middle East and North African countries. The result is also similar to that of Singhania and Saini (2021) for 21 developed and developing countries. The results also some studies found the validity of the PHaloH (Saqib et al., 2023) in 16 EU countries; and Balcılar et al. (2023) in 34 African countries. Finally, a stream of literature found mixed results between FDI flows and ED including Apergis et al. (2023) for BRICS countries, Ahmad et al. (2021) for Chinese provinces, Benzerrouk et al. (2021) for 31 developed and 100 developing countries. Finally, the relationship between FDI and ED has been investigated, yielding different results. Apergis et al. (2023) addressed this issue for BRICS countries, Ahmad et al. (2021) for Chinese provinces, and Benzerrouk et al. (2021) for 31 developed and 100 developing countries. The results of the empirical papers that investigate PHavenH in different countries and regions using different econometric methodologies are presented in Table 2.

Table 2: Literature review summary for PHavenH and PHaloH

Authors	Period of study	Country	Variables	Methodology	The main results
Ozkan et al. (2023)	1990-2019	China	Carbon efficiency, FDI, GDP, energy consumption efficiency, trade openness	Dynamic ARDL simulations approach	Verify PHavenH
Apergis et al. (2023)	1993-2012	BRICS countries	CO2, FDI, GDP, energy use, trade activities, total population, urban population, renewable energy consumption	GMM	Verify PHavenH for Denmark and the UK, and verify PHaloH for France, Germany, and Italy.
Saqib et al. (2023)	1990-2020	16 European countries	Ecological footprints, FDI, GDP, energy structure, renewable energy, human capital	CS-ARDL model	Verify PHaloH
Balcılar et al. (2023)	1990-2017	34 African countries	CO2, FDI, natural resource rents, GDP, renewable energy, government stability	SYS-GMM	Verify PHaloH
Balsalobre-Lorente et al. (2022)	1990-2019	Portugal, Ireland, Italy, Greece, and Spain	CO2, economic complexity index, FDI, renewable energy use, and urbanization	Dynamic OLS	Support PHavenH
Danish and Ulucak (2022)	1990-2017	China	CO2, energy innovation, FDI	Dynamic autoregressive distributed lag simulation method	Reject PHavenH
Danish et al. (2021)	1993-2010	China	CO2 emissions, per capita GDP, FDI, and nuclear energy	ARDL	Verify PHavenH
Ahmad et al. (2021)	1998-2016	28 Chinese provinces	CO2, FDI, GDP	CCE method	Support for PHaloH at aggregated levels and PHavenH at fifteen provinces
Singhania & Saini (2021)	1990-2016	21 developed and developing countries	CO2, GDP, energy consumption, trade openness, FDI, financial development, institutional framework	Panel GMM	Verify PHavenH, especially in developing countries

Koksal & Cetin (2021)	1985-2017	Turkey	Pollution limit, GDP, GDP squared, FDI, urbanization, financial development and ecological footprint	Multivariate regression analysis	Verify PHavenH
Balsolobre-Lorente et al. (2021)	1990-2019	PIIGS countries	FDI, renewable energy, urbanization, and carbon emissions	DOLS	Verify PHavenH.
Udeagha & Ngepah (2021)	1960-2016	South Africa	CO2 emissions, trade openness, FDI, energy consumption, industrial value-added, technological innovation	ARDL	PHavenH exists in South Africa.
Bulut et al. (2021)	1970-2016	Turkey	CO2, FDI, GDP electricity production	Cointegration	PHavenH is valid in Turkey.
Mike (2020)	1970-2015	Turkey	CO2, Nitrogen oxide, total greenhouse gas, FDI, GDP, energy consumption	ARDL	PHavenH exists.
An et al. (2021)	2003-2018	64 Belt the Road Host countries	CO2, GDP, Chinese outward FDI, people connectivity index, technology innovation	FMOLS, D-OLS, FE-OLS	Verify PHavenH
Benzerrouk et al. (2021)	1980-2016	31 developed and 100 developing countries	CO2, trade openness, FDI, and GDP	Panel GMM	PHavenH is valid in developing countries and PHaloH is considered for developed countries.
Sahin, Gokdemir & Ayyıldız (2019)	1990-2015	Turkey	CO2, FDI, industry value-added, trade	Cointegration- VECM	PHavenH is valid for Turkey.
Shahbaz, Balsalobre-Lorente and Sina (2019)	1990-2015	MENA countries	CO2, GDP per capita, FDI, and biomass consumption	GMM	Verify PHavenH
Mert et al. (2019)	2001-2014	26 European countries	CO2, GDP, renewable and non-renewable energy utilization, FDI	Panel ARDL approach	Verify PHavenH
Shao et al. (2019)	1982-2014	BRICS and MINT countries	CO2, GDP per capita, energy consumption, trade openness, and urbanization	Panel group mean fully modified ordinary least squares	Reject PHavenH
Destek & Okumus (2018)	1982-2013	Ten newly industrialized countries	Real income, FDI, energy consumption, ecological footprint	Panel data	There is a U-shaped relationship between FDI and ecological footprint.
Mike & Kardaslar (2018)	2000-2015	102 countries	Three different pollution indicators (CO2, NO2, and total greenhouse gas), FDI, GDP, and energy use	Panel GMM	PHaloH is valid for low-middle-income, upper-middle-income, and high-income countries. PHavenH is valid for low-income countries.
Shazbaz et al. (2015)	1975-2012	High-, middle-, and low-income countries	FDI, CO2, GDP, energy consumption	FMOLS	Verify PHavenH
Solarin et al. (2017)	1980-2012	Ghana	CO2, GDP, urban population, energy consumption, renewable energy consumption, fossil fuel energy consumption, institutional quality, urbanization and trade openness	ARDL	PHavenH does exist in Ghana.
Sun et al. (2017)	1980-2012	China	CO2, energy use, financial development, trade openness, economic freedom, FDI, GDP	ARDL	PHavenH is valid in China

Zeren (2015)	1970-2010	USA, France, United Kingdom, and Canada	CO2, FDI	FMOLS- CCR cointegration	PHavenH is only valid for Canada. PHaloH is valid for the USA, France, and the United Kingdom.
Merican et al. (2007)	1970-2001	The ASEAN-5 nations	CO2, GDP, manufacturing value-added, FDI	Time series ARDL	PHavenH is valid for Malaysia, Thailand, and the Philippines.

3. Dataset and Methodological Framework

This study investigated the effect of Foreign Direct Investment (FDI) and Renewable Energy Consumption (REC) on Carbon Emissions (CE) for the period 1990-2020, focusing on seven developing countries: China, India, Brazil, Mexico, Turkey, South Africa, and Malaysia. The analysis period was selected based on the availability of data for these countries. As indicated by the literature review, carbon emissions were chosen as the dependent variable due to their significant share in greenhouse gas emissions (Cetin and Ecevit, 2015) and their role as an indicator of environmental pollution. To test the Pollution Haven Hypothesis (PHH), REC was included as an independent variable alongside FDI. REC is a variable frequently encountered in the literature (Solarin et al., 2017; Mert et al., 2019; Balsalobre-Lorente et al., 2021; Balsalobre-Lorente et al., 2022; Cetin et al., 2023b). The predicted logarithmic model is as follows:

$$lnCO2_{i,t} = \beta_0 + \beta_1 lnFDI_{i,t} + \beta_2 lnREN_{i,t} + \varepsilon_{i,t} \qquad (1)$$

The variables depicted in Equation 1 are defined in Table 3.

Table 3: Definition of Variables and Sources

Variable Name	Definition	Sources
$lnCO_2$	CO2 emissions (kt)	WB-WDI
lnFDI	Foreign direct investment, net inflows (% of GDP)	WB-WDI
lnREN	Renewable energy consumption (% of total final energy consumption)	WB-WDI

It is very important to detect the existence of CSD in panel data at the first stage of econometric analysis in order to decide which of the first or second generation unit root test. Pesaran (2004) CD statistics is used to detect the existence of CSD N(0,1) for N →∞ and T sufficently large. The CD test statistic is as follows:

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right) \sim N(0,1) i, j \qquad (2)$$

The term $\hat{\rho}_{ij}$ denotes the correlation for each residual series obtained from simple regression estimates.

Before proceeding with the model estimation, testing the homogeneity of the slope parameters is essential. Tests for homogeneity were conducted using the delta tests Blomquist and Westerlund (2013). This test can give stronger predictions against varying variance and serial correlation in regression errors. As a result of the test, the acceptance of the H_1 reveals that the series are heterogeneous. This test is shown in Equations 3, 4, and 5 (Shahbaz et al. 2023; Ullah et al., 2023):

$$\Delta_{HAC} = \sqrt{N}\left(\frac{N^{-1}S_{HAC} - k}{\sqrt{2k}}\right) \qquad (3)$$

$$S_{HAC} = \sum_{i=1}^{N} T(\hat{\beta}_i - \hat{\beta})'(\hat{O}_{iT}V_{iT}^{-1}\hat{O}_{iT})(\hat{\beta}_i - \hat{\beta}) \qquad (4)$$

$$\hat{\beta} = \left(\sum_{i=1}^{N} T\hat{O}_{iT}V_{iT}^{-1}\hat{O}_{iT}\right)^{-1}\sum_{i=1}^{N}\hat{O}_{iT}\hat{V}_{iT}^{-1}X_i'M_T y_i \qquad (5)$$

This study utilized the CADF test developed by Pesaran (2007). The CADF regression is as follows (Baltagi, 2013):

$$\Delta y_{it} = \alpha_i + \rho_i^* y_{i,t-1} + d_0\bar{y}_{t-1} + \sum_{j=0}^{p} d_{j+1}\Delta\bar{y}_{t-j} + \sum_{k=1}^{p} c_k \Delta y_{i,t-k} + \varepsilon_{it} \qquad (6)$$

The existence of cointegration between series was investigated by the residual-based cointegration methods of Kao (1999), Pedroni (2004), and Westerlund (2005). In addition, Westerlund's (2007) cointegration test was also used in this study. In this test, the H_0 that asserts there is no cointegration between the variables is tested against the the H_1 by determining whether the error correction coefficient is equal to zero. In this approach, the Pt and Pa statistics test the H_1 that the panel as a whole is cointegrated, as opposed to the H_0, which suggests that there is no error correction; The Gt and Ga statistics test the heterogeneous H_1 that error correction is involved for at least one of the constituent units of the panel the error correction model is as follows (Persyn and Westerlund, 2008):

$$\Delta y_{it} = \delta_i' d_t + \alpha_i(y_{it-1} + \beta_i' X_{it-1}) + \sum_{j=1}^{pi} \alpha_{ij} \Delta y_{it-j} + \sum_{j=0}^{pi} \gamma_{ij} \Delta X_{it-j} + e_{it} \quad (7)$$

After determining the CSD, slope heterogeneity, and cointegration relationship in the panel data, long-term estimation was made with the AMG estimator developed by Eberhardt and Teal (2010) and Eberhardt and Bond (2009). The two-stage process inherent in this method is shown in equations 8 and 9:

$$\Delta X_{it} = \delta_i + \beta_i \Delta Y_{it} + \gamma_i A_t + \sum_{t=2}^{T} \delta_i \Delta D_t + \varepsilon_{it} \quad (8)$$

$$\hat{\beta}_{AMG} = N^{-1} \sum_{i=1}^{N} \hat{\beta}_i \quad (9)$$

The causality test of D-H (2012) gives consistent results in heterogeneous panels with CSD. This test is shown in equation 10 (Dumitrecu and Hurlin, 2012):

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \beta_{ik} y_{i,t-k} + \sum_{k=1}^{K} \gamma_{i,k} X_{i,t-k} + \varepsilon_{it} \quad (10)$$

4. Empirical Findings and Evaluation

4.1. Summary statistics and correlation analysis results

In Table 4, the variable with the highest value in all of the summary statistics is lnCO2. The variable with the lowest value is the lnFDI variable, except for the skewness value. When the correlation between the variables is evaluated in Table 4, a positive correlation exists among lnFDI, lnREN, and lnCO2.

Table 4: Summary statistics and correlation matrix

	lnCO2	**lnFDI**	**lnREN**
Mean	13.166	1.378	2.796
Median	12.870	1.500	2.695
Maximum	16.208	2.866	3.969
Minimum	10.908	-.060	.672
Std. Dev.	1.183	.679	.820
Skewness	1.028	-.276	-.375
Kurtosis	3.426	2.108	2.449
Obs.	217	217	217
lnCO2	1.000		
t-Statistic	-		
lnFDI	.125	1.000	
t-Statistic	1.853***	-	
lnREN	.318	-.259	1.000
t-Statistic	4.926*	-3.943*	-

Note: *, **, and *** represent significance at 1%, 5%, and 10% levels, respectively.

4.2. CSD and slope homogeneity test results

The results of the CSD test concerning the variables analyzed are displayed in Table 5. According to the results of the CD test developed by Pesaran (2004) in Table 5, the H_0, which states that there is no CSD, is rejected. The results obtained show that there is CSD for all variables.

Table 5: CSD analysis results

Variables	CD-test	P-value
lnCO2	24.198*	.000
lnFDI	4.008*	.000
lnREN	16.441*	.000

The slope homogeneity test results of the estimated model are shown in Table 6. The results show that the H_0, which expresses the existence of slope homogeneity, will be rejected, so the slope coefficients in the model are heterogeneous at the 1% significance level.

Table 6. Blomquist and Westerlund test results

	Model 1
$\tilde{\Delta}$	3.870* (.000)
$\tilde{\Delta}$adj	4.193* (.000)

4.3. Unit root and cointegration test results

The results of the CADF panel unit root test in Table 7 indicate that all variables are stationary at the I(1) level for both models.

Table 7: CADF test results

Variables	CADF for constant		CADF for constant & trend	
	I(0)	I(1)	I(0)	I(1)
lnCO2	-1.913	-3.238*	-1.886	-3.156*
lnFDI	-1.741	-2.403**	-2.324	-2.896**
lnREN	-2.016	-2.341**	-2.464	-3.540*

Note: *, **, and *** denote significance at 1%, 5%, and 10% levels, respectively.

In the study, Kao (1999), Pedroni (2004), and Westerlund (2005) cointegration analysis were performed before moving on to the long-term prediction. In Table 8. It is seen that there is a cointegration relationship between the variables at the 1% and 5% importance levels for all tests in the Kao (1999) cointegration analysis. In the Pedroni (2004) analysis, only the Modified Phillips-Perron t-test confirms the cointegration relationship at the 5% significance level. In Westerlund's (2005) cointegration analysis, there is a cointegration relationship. Finally, in the Westerlund (2007) test, the Gt test statistic confirms the cointegration relationship.

Table 8: Cointegration analysis.

Westerlund (2007)	Z-value	P-value
Gt	-56.978*	.000
Ga	2.807	.998
Pt	4.686	1.000
Pa	1.353	.912
Kao (1999)	Statistic	P-value
MDF t	2.317*	.010
DF t	3.370*	.000
ADF t	3.521*	.000
UMDF t	1.834**	.033
UDF t	2.335*	.009
Pedroni (2004)	Statistic	P-value
MPP t	1.651**	.049
PP t	.616	.268
ADF t	1.102	.135
Westerlund (2005)	Statistic	P-value
Variance Ratio	2.209*	.013

Note: The cointegration tests lessen the effect of CSD structure.

4.4. Long-term and causality test results

AMG estimators provide unbiased and more efficient estimates in the presence of cross-section depenency and slope heterogeneity (Eberhardt and Bond 2009). Table 9 gives the AMG estimation results for the panel-wide. The effect of the lnFDI variable on the lnCO2 variable was negative and statistically significant. A 1% increase in FDI results in a 0.019% decrease in lnCO2. In other words, FDI in seven developing countries have an improving effect on EQ. According to the panel-wide results, the PHavenH does not apply in the countries concerned. This result has emerged parallel to the results of numerous studies conducted in the literature (Balcılar, 2023) for 34 African countries, Saqib et al. (2023) for 16 European countries, Shao et al. (2019) for BRICS and MINT countries and Mike and Kardaslar (2018) for different income group countries except for low-income group). On the other hand, the effect of the lnREN on the lnCO2 is negative. A 1% increase in lnREN indicates a 0.602% reduction in lnCO2. Therefore, REC improves EQ. Table 9 shows that the EQ improvement effect of REC is higher than FDI.

Table 9: AMG Estimation Results

	Coefficient	P-Value
lnFDI	-.019*	.008
lnREN	-.602*	.001
Constant	14.646*	.000
Wald $\chi 2$	18.83	
Prob > $\chi 2$	.000	
RMSE	.037	
Number of Observations	217	
Number of Countries	7	

In Table 10, when the country-specific AMG forecast results are evaluated, FDI reduces EP in the Indian, Brazilian, and Malaysian economies. Therefore, the PHaloH is valid in these countries. On the other hand, FDI causes ED in South Africa. Therefore, in this country, the PHavenH applies.

In Table 10, the country-specific AMG forecast results indicate that FDI reduces EP in the Indian, Brazilian, and Malaysian economies. Consequently, the PHaloH is valid in these countries. Conversely, in South Africa, FDI leads to ED, suggesting that the PHavenH applies in this context. These results are similar to those of Apergis et al. (2023) for BRICS countries, Ahmad et al. (2021) for Chinese provinces, and Zirverouk et al. (2021) are similar to the results of their analysis for 31 developed and 100 developing countries. Another country-specific result is that REC has an improving effect on EQ in all countries included in the analysis. It can be said that renewable energy is an important factor in reducing CE in these countries. As Çetin et al. (2023) pointed out, renewable energy is important in reducing EP. Similar results are found in this direction in the literature (Alvarez-Herranz et al., 2017; Magazzino et al., 2022; Chen et al., 2023; Karimi Alavijeh et al., 2023) and therefore the increase in environmentally friendly energy investments in terms of EP in a way that supports the PHaloH will have beneficial results for the sustainable development of all countries.

Table 10: Country-Specific AMG Estimation Results

Countries	lnFDI	lnREN	Constant
China	-.023 (.208)	-.668* (.000)	16.996* (.000)
India	-.031* (.015)	-1.183* (.000)	17.938* (.000)
Brazil	-.049* (.000)	-1.380* (.000)	17.546* (.000)
Mexico	.035 (.110)	-.553* (.000)	13.953* (.000)
Turkey	-.036 (.168)	-.254* (.000)	12.636* (.000)
South Africa	.025** (.042)	-.336* (.000)	13.355* (.000)
Malaysia	-.082* (.023)	-.302* (.000)	11.960* (.000)

Note: The *p*-values are given in parentheses.

The analysis from Table 11 using the D-H panel causality test revealed bidirectional causality between lnFDI and lnCO2, and unidirectional causality from lnREN to lnCO2.

Table 11: Dumitrescu-Hurlin test results

Hypothesis	W-Stat.	Zbar-Stat.	p-value	Causality
lnFDI⇔lnCO2	14.148	5.055*	0.000	lnFDI↔lnCO2
LnCO2⇔lnFDI	14.451	4.267*	0.000	
lnREN⇔lnCO2	16.513	5.630*	0.000	lnREN→lnCO2
lnCO2⇔lnREN	10.086	1.380	0.167	

The symbols →, and ↔ indicate a unidirectional and bidirectional, respectively.
The optimal lag length is selected by AIC.

5. Concluding Remarks and Policy Suggestions

In the process of globalization, the liberal idea of laissez-faire, laissez-faire, in line with the classical doctrine, has become the dominant view in the world after the 1990s. We observe that during this process, capital moves freely between countries to areas it finds profitable. Reasons such as cheap labor force, foreign capital incentives, and more flexible environmental regulations can be listed among the factors that create this profitable environment.

However, many reasons such as excessive use of resources due to production, energy use due to fossil fuels, trade openness, and urbanization lead to EP. Within the framework of global warming and climate change, global environmental agreements aim to encourage countries to be environmentally sensitive and focus on activities that will reduce global warming. Environmentally sustainable growth strategies hold significant importance, particularly within the United Nations' SDG framework. The laissez-faire, laissez-faire policy of liberal ideology may face restrictions in terms of environmental regulations. The PHavenH states that dirty production sectors shift their production to countries with more flexible practices in terms of environmental standards. The development of production technologies in these sectors will be an environmental gain both for the countries they go to and for the whole world, and the PHaloH will be valid.

Based on the analysis results, the impact of the lnFDI on the lnCO2 was found to be negative. A 1% increase in lnFDI results in a 0.019% reduction in lnCO2. In other words, FDI in seven developing countries have an improving effect on EQ. According to the panel-wide results, the PHavenH is not valid in the relevant countries. On the other hand, the effect of the lnREN on the lnCO2 is negative. A 1% increase in lnREN indicates a 0.602% reduction in lnCO2. In this study, when the AMG forecast results are evaluated on a country-by-country basis, FDI reduces EP in the Indian, Brazilian, and Malaysian economies. Therefore, the PHaloH is valid in these countries. On the other hand, FDI causes ED in South Africa. Therefore, in this country, the PHavenH applies. On the other hand, according to the results of the D-H panel causality test, a bidirectional causality relationship was determined between lnFDI and lnCO2, while a unidirectional causality relationship was determined from lnREN to lnCO2. To attract the FDI they need for sustainable growth, these countries will need to take measures that will not pollute the environment but will make the country attractive with different supports. In addition to increasing environmentally friendly FDI that will support environmentally sensitive growth, which is included in the SDG of the United Nations, policies to increase renewable energy investments, which are important in terms of climate change, will also create a win-win result for the whole world.

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