Akademik Araştırmalar ve Çalışmalar Dergisi 2025, 17(32), 134-149
Journal of Academic Researches and Studies 2025, 17(32), 134-149
https://doi.org/10.20990/kilisiibfakademik.1634138

Makale Türü: Araştırma Makalesi
Paper Type: Research Paper

Geliş Tarihi/Received Date: 05.02.2025
Kabul Tarihi/Accepted Date: 05.05.2025

Pollution Haven, Pollution Halo, or Pollution Hell? The Impact of Foreign Direct Investment on CO2 Emission and Temperature Rise in Fragile Five Countries

Kirlilik Cenneti, Kirlilik Halesi veya Kirlilik Cehennemi? Doğrudan Yabancı Yatırımların Kırılgan Beşli Ülkelerindeki CO2 Emisyonu ve Sıcaklık Artışı Üzerindeki Etkisi

Emre ÖZSALMAN[1], Ömer Faruk DERİNDAĞ[2], Tayfur BAYAT[3]

Abstract

Purpose: The purpose of this study is to investigate how foreign direct investment (FDI) affects the environmental quality of the Fragile Five countries, with a particular emphasis on how it may transfer ecologically damaging sectors to host countries. The link between FDI inflow, CO2 emissions, and temperature rise in the selected countries between 1970 and 2021 is specifically examined.

Design/methodology: The Panel Fourier Granger Causality Test is used in the study to examine the causative relationships among temperature rise, CO2 emissions, and FDI. In order to effectively approximate the structural breaks in the series, Bahmani-Oskooee et al. (2014) Panel Unit Root Test with Sharp and Smooth Breaks was used. Additionally, the Pollution Haven Hypothesis (PHH) is tested for the selected countries.

Findings: In the Fragile Five countries, the findings show a causal relationship between CO2 emissions and temperature rise, as well as between FDI inflow and CO2 emissions. PHH for these countries is supported by these findings, which also imply that FDI inflows worsen environmental deterioration and contribute to warming.

Originality/value: This study contributes to the body of literature by offering empirical proof of the long-term environmental effects of FDI inflows into the Fragile Five countries. Additionally, the PHH is tested for selected countries and one-way causality from FDI to CO2 emission reveals that PHH is valid for selected countries.

Keywords: Foreign Direct Investment, CO2 Emission, Temperature Rise, Pollution Haven

Öz

Amaç: Bu çalışmanın amacı, doğrudan yabancı yatırımın (DYY) Kırılgan Beşli ülkelerindeki çevresel kaliteyi nasıl etkilediğini ve özellikle ekolojik olarak zararlı sektörlerin ev sahibi ülkelere transferini nasıl sağladığını araştırmaktır. Seçilen ülkelerde 1970-2021 yılları arasında DYY girişi, CO2 emisyonları ve sıcaklık artışı arasındaki ilişki özellikle incelenmiştir.

Tasarım/metodoloji: Çalışmada sıcaklık artışı, CO2 emisyonları ve DYY arasındaki nedensel ilişkileri incelemek için Panel Fourier Granger Nedensellik Testi kullanılmıştır. Serilerdeki yapısal kırılmaları etkili bir şekilde tahmin etmek için Bahmani-Oskooee ve ark. (2014) tarafından geliştirilen Keskin ve Yumuşak Kırılmalı Panel Birim Kök Testi uygulanmıştır. Ayrıca, seçilen ülkeler için Kirlilik Sığınağı Hipotezi (KSH) test edilmiştir.

Bulgular: Kırılgan Beşli ülkelerinde, CO2 emisyonları ile sıcaklık artışı ve DYY girişi ile CO2 emisyonları arasında nedensel bir ilişki olduğu bulunmuştur. Bu bulgular, DYY girişlerinin çevresel bozulmayı kötüleştirdiğini ve sıcaklık artışına katkıda bulunduğunu ortaya koyarak KSH'nin bu ülkeler için geçerli olduğunu desteklemektedir.

Özgünlük/değer: Bu çalışma, Kırılgan Beşli ülkelerine yönelik DYY girişlerinin uzun vadeli çevresel etkilerine dair ampirik kanıtlar sunarak literatüre katkıda bulunmaktadır. Ayrıca, seçilen ülkeler için KSH test edilmiş ve DYY'den CO2 emisyonlarına tek yönlü nedensellik, KSH'nin bu ülkeler için geçerli olduğunu ortaya koymuştur.

Anahtar Kelimeler: Doğrudan Yabancı Yatırım, CO2 Emisyonu, Sıcaklık Artışı, Kirlilik Sığınağı

[1]Arş. Gör, İnönü Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, Uluslararası Ticaret ve İşletmecilik, emre.ozsalman@inonu.edu.tr, ORCID: 0000-0003-3620-1122
[2]Doç. Dr., İnönü Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, Uluslararası Ticaret ve İşletmecilik, omer.derindag@inonu.edu.tr, ORCID: 0000-0002-6693-0628
[3]Prof. Dr., İnönü Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, Uluslararası Ticaret ve İşletmecilik, tayfur.bayat@inonu.edu.tr, ORCID: 0000-0002-4427-0999

1. INTRODUCTION

The initial phase of economic development is often characterized by a surge in Carbon Dioxide Emissions (CO2) (Bahse et al., 2017; Fan et al., 2011; Zhang & Zhou, 2016) attributed primarily to early industrialization and an increase in energy consumption (Tanga & Tan, 2015). However, a pivotal transition occurs as countries achieve higher income levels, steering towards the adoption of greener policies and a reduction in their emissions footprint. The Environmental Kuznets Curve (EKC) (Cole, 2004) postulates an inverted U-shaped relationship between a country's income and its environmental degradation (ED), offering a conceptual framework to analyze this transition.

The phenomenon that fossil fuel consumption triggers economic growth while also leading to significant CO2 emissions is crucial to reconsider, especially within the context of the developing countries. This indicator underscores the critical need for a comprehensive understanding of the interplay between economic development, foreign direct investment (FDI), CO2 emissions, and the ancillary factors of urbanization, innovation, and governance. It advocates for informed policy decisions and strategic planning as instrumental in navigating the path towards sustainable development for emerging markets and the global community at large, in confronting the challenges posed by global warming (Murta & Ito, 1996) since the combustion of fossil fuels and the resulting CO2 intensifies global warming and climate change, posing an urgent threat to the international community (Das et al., 2011).

The phrase "Fragile Five" was coined in August 2013 by a Morgan Stanley research analyst to describe five developing countries, consisting of Brazil, India, Indonesia, Türkiye and South Africa, which have grown overly reliant on erratic foreign investment to support their future growth (Chadwick, 2018). The "Fragile Five" countries seek foreign investments due to their current account deficits and relatively high inflation rates. In response, these countries have implemented policies aimed at attracting FDI. Additionally, their status as emerging economies with significant growth potential further enhances their appeal to investors.

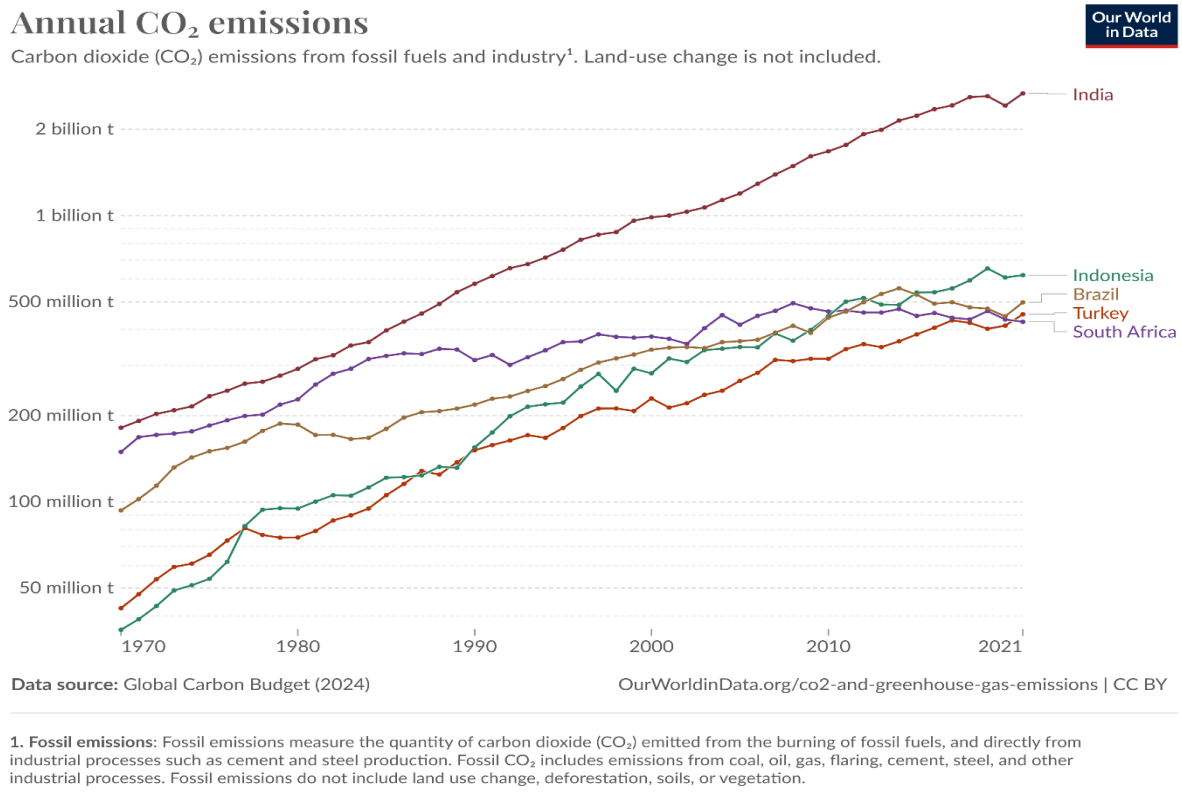
While FDIs are economically beneficial to the host country, the environmental impacts of FDIs still remain a controversial issue. To reveal the controversial issue, the pollution haven hypothesis (PHH) has been developed to frame discussions in the environmental economics literature about the impact of FDI on ED (Botanic et al., 2007). The PHH is concentrated on how FDI degrades the quality of the environment and relies on the supposition that when industrialized advanced economies seek to increase and relocate their production capacity. By doing so, international companies strive to invest in countries where environmental regulations (ER) are weak, and carbon emissions are not priced (not penalized). Thus, it is possible for polluting businesses to move from developed to developing countries (Bulut et al., 2021).

Even if developed countries have taken steps to lower their own carbon emissions, it is unrealistic to assert that global emission reduction initiatives have been very effective. As shown in Figure 1, all five of the countries that our study examined have concerningly high emission rates. While India stands out from the rest of these five countries, the emission rates of the other four countries are very similar. This is further evidence that the economies of the so-called "Fragile Five" countries are similar.

Contrary to convention, critically examining the dualistic nature of trade, FDI, and financial development on CO2 emissions would be beneficial (Cole et al., 2017; Zheng et al., 2023). The discussion includes the possibility of technology transfer and green energy investments, recognizing the complex and context-specific results of these relationships that allow the development of the pollution halo hypothesis (Cole, 2004; Cole & Elliott, 2005). The vast analysis on pollution halo bifurcates the positive aspects of FDI, such as economic augmentation and technological advancement, from its negative ramifications, including potential escalations in emissions and the exploitation of lax ER by multinational corporations (Islam et al., 2021).

This article examines the effects of FDI on CO2 emissions, testing the pollution haven and pollution halo hypotheses in the "Fragile Five" countries. It also illustrates the noteworthy influence of CO2 emissions on temperature rise in a selected group of countries using Fourier functions developed by Bahmani-Sooke et al. (2014)and Granger Fourier Causality test.

Figure 1: Annual CO_2 emissions by country



Source: (Global Carbon Budget, 2023)

Even if developed countries have taken steps to lower their own carbon emissions, it is unrealistic to assert that global emission reduction initiatives have been very effective. As shown in Figure 1, all five of the countries that our study examined have concerningly high emission rates. While India stands out from the rest of these five countries, the emission rates of the other four countries are very similar. This is further evidence that the economies of the so-called "Fragile Five" countries are similar.

Contrary to convention, critically examining the dualistic nature of trade, FDI, and financial development on CO2 emissions would be beneficial (Cole et al., 2017; Zheng et al., 2023). The discussion includes the possibility of technology transfer and green energy investments, recognizing the complex and context-specific results of these relationships that allow the development of the pollution halo hypothesis (Cole, 2004; Cole & Elliott, 2005). The vast analysis on pollution halo bifurcates the positive aspects of FDI, such as economic augmentation and technological advancement, from its negative ramifications, including potential escalations in emissions and the exploitation of lax ER by multinational corporations (Islam et al., 2021).

This article examines the effects of FDI on CO2 emissions, testing the pollution haven and pollution halo hypotheses in the "Fragile Five" countries. It also illustrates the noteworthy influence of CO2 emissions on temperature rise in a selected group of countries using Fourier functions developed by Bahmani-Sooke et al. (2014)and Granger Fourier Causality test.

2. LITERATURE REVIEW AND THEORETICAL BACKGROUND

In most cases, both donors and host countries may profit from FDI. For instance, the host countries might get financial support, innovative technology and managerial abilities, jobs, and a workforce with enhanced capabilities. In contrast, the donor country benefits from those resulting from factor costs and seeks to combine low-cost labor, dependable infrastructure, and the stability of various

institutional, political, and legal environments (Van Den Bulken & Zhang, 1998). On the other hand, FDI might affect the environmental quality of the host country. Regarding how FDI affects the host country's environmental quality, there are two opposing viewpoints (Liang, 2008). It is thought to have a favorable impact on the environment of the hosts country, nevertheless, it is contended that while FDI quickens the pace of economic expansion, it may also have unfavorable repercussions for the environment of the host countries since it causes an increase of CO2 (He, 2006; İviyor & Arminen, 2014).

The rise in CO2 and other Green House Gas (GHG) in the atmosphere has several detrimental effects in addition to environmental deterioration. Among the principal adverse consequences is a rise in Temperature (Y. Chen et al., 2014; Das et al., 2011). Moreover, the persistent rise in greenhouse gas concentrations and CO2 rise in the atmosphere is anticipated to cause climate shifts, which in turn would impact ecosystems and perhaps cause catastrophic disruptions to human health, living standards, and economic activity (Golani, 2009; Sharma et al., 2006). This section will first describe the relationship between FDI and CO2, and then it will explore the relationship between CO2 and Temperature rise.

2.1. FDI and CO2 Nexus (Pollution Haven- Pollution Halo Hypothesis)

FDI inflows boost the economy of the host country, but they also increase pollution from unregulated industrial activity (Kan & Ozturk, 2020). Developing countries purposefully downplay ER in order to draw in international capital. Thus, to take advantage of the few strict ER, global investors typically relocate their businesses to less wealthy countries (Mabet & McNally, 1998). Thus, countries with high pollution levels have seen a rise in foreign investment because they have lax environmental restrictions that attract overseas polluting firms (Hoffmann et al., 2005; Karslıya & Riddel, 2010; Waldkirch & Gopinath, 2008). This trade shift has been criticized for failing to take into consideration trade patterns, which in and of itself may help to explain, at least in part, why pollution is declining in high-income economies while rising in low-income ones. The hypothesis is known as pollution haven (PHH) (Cole, 2004b). Over the past few decades, the environmental economics literature has examined the impact of FDI on ED, primarily in relation to the PHH. The PHH is concentrated on how FDI degrades the quality of the environment.

Previous research has extensively examined the association between environmental pollution and FDI, as well as a few other variables (Cole, 2004; Zheng et al., 2023). The most well-known and convincing idea among recent research supporting the detrimental effects of FDI on the environment is PHH (Sun et al., 2017). ED caused by FDI can be attributed to multiple factors. The first explanation is that heavy industries receive the majority of investments from foreign companies. Lax ER, inadequate infrastructure, and the need for investment in the industrial sector are major factors that draw foreign investments to underdeveloped or developing countries. It also has the greatest impact on international businesses' desire to relocate their ecologically hazardous production, often referred to as "dirty sectors", outside of the nation in order to maintain their reputation (Cole, 2004b). As nations become wealthier, they export pollution by moving their Emissions-Intensive Industries (EII) such as iron and steel, cement, aluminum, and textiles to less developed countries (Poelhekke and Van der Ploeg, 2015). The second reason is that multinational corporations strategically relocate their operations to host countries with more permissive regulatory frameworks to mitigate the financial burden associated with stringent environmental standards in their home countries. This relocation results in reduced marginal productivity for highly polluting goods. Such shifts occur as home countries implement rigorous regulations to address environmental challenges (Singhania & Saini, 2021).

The PHH has been the subject of numerous studies, but the situation of Fragile Five has received less attention. Bağlıtaş and Öztürk Yaprak (2019) tested the validity of PHH in the Fragile Five countries. However, the findings failed to come to a consensus regarding PHH for this set of countries. According to results, while PHH is valid in Türkiye and Indonesia, in Brazil, India and South Africa PHH is not valid. Due to the lack of studies on PHH in Fragile Five countries another country group examined for the purpose of literature review was BRICS (Brazil, Russia, India, China

and South Africa), since it covers countries similar to the Fragile Five countries. The BRICS countries, which comprise sizable rising economies and account for about half of the world's population, are major drivers of global growth, making FDI crucial to their economies. However, these countries rose to become the world's biggest energy users and among the top 20 pollutants of the entire world (Menegaki & Ozturk, 2016). In this regard the relationship between FDI, carbon emissions and ED has become quite prominent. While some studies obtained results that FDI increases CO2 emissions and confirmed the validity of PHH in BRICS countries (Apergis et al., 2023; Chaudhry et al., 2022; Wen et al., 2022), Shao et al. (2019) did not validate PHH in the BRICS countries, whereas Yilanci, Gorus, et al. (2019).'s study only verified PHH for India. Lastly, there are a number of research investigating PHH's validity for Türkiye. Bulut et al. (2021), Terzi and Pata (2020), and Seker et al. (2015) concluded that PHH is valid for Türkiye. Similarly,Balsalobre-Lorente et al. (2019) and Bakirtas and Cetin (2017) discovered data supporting PHH for Indonesia.

While some data suggests that FDI could have a negative impact on the environment, other research in the literature suggests that multinational corporations may be able to reduce environmental pollution intensities in the host country by using advanced and environmentally friendly technologies in their production processes, along with improved management and operational practices (Zarsky, 1999). Furthermore, several studies emphasize that, in comparison to domestic businesses, international corporations have access beneficial technologies (Eskeland & Harrison, 2003; Lee, 2013). Concerning this assumption, it is widely deduced that multinational companies participating in FDI have the ability to introduce sophisticated technology and elevated production standards to the countries they invest in, consequently aiding in the decrease of regional emissions of pollutants (Pao & Tsai, 2011; Zhu et al., 2016). As a result, FDI might reduce environmental pollution in a country by introducing cleaner technologies to the host country. The literature refers to this point of view as the pollution halo hypothesis (Seker et al., 2015). Shahbaz et al. (2013). discovered that since FDI helps transfer energy-efficient technologies to local companies, globalization had the opposite effect on CO2 emissions in Turkey. Similarly, the pollution halo theory was further supported by Mert & Caglar (2020). Authors discovered that increases in FDI in Turkey resulted in a short- and long-term decline in the country's rate of emission growth. The pollution halo theory is also supported by Zhang and Zhou's (2016b) finding that FDI inflows and CO2 emissions are inversely correlated. Lastly, Yilanci et al. (2023) investigated the relationship between FDI and the fishing environment in Indonesia and concluded that FDI has a positive impact on the fishing sector. By this results authors claimed that PHH is not valid in fishing environment in Indonesia.

2.2. CO2 Emission and Temperature Rise Nexus

Since the temperature has risen dramatically over time, climate change has emerged as one of the most important challenges on a global scale. Unprecedented human activity has led to a sharp rise in greenhouse gas emissions worldwide since the late 1700s. 2005 saw the highest levels of CO2 and CH4 in the atmosphere in the previous 65 million years (IPCC, 2007). Thus, researchers have given a great deal of attention to the question of whether Temperatures influence economic activity and vice versa (X. Chen & Fang, 2024).

Researchers have connected the rise in carbon dioxide and other greenhouse gases (GHG) to the Temperature trend that began in the 20th century. Additionally, as greenhouse gas concentrations in the atmosphere continue to rise, ecosystems will likely vary due to climate change, which might have disastrous effects on people's health, living standards, and economic activity (Sharma et al., 2006). The average surface Temperature has increased globally by 0.4–0.8 C in the past century (Goklany, 2009). And, both the scientific and public populations have identified CO2 emissions as the factor most strongly associated with global warming. Both past data and projected climate models demonstrate that the rise in CO2 concentrations in the atmosphere is (roughly) closely correlated with global warming. To be more precise, for every 10 ppm (parts per million) increase in CO2 concentrations, the mean global temperature rises by 0.1 °C. (Fakta o klimatu, 2024).

Increasing carbon emissions also increases the mean Temperature increase. However, the reasons for countries' increasing carbon emissions vary. Das et al. (2011) investigated the relationship

between rising Temperatures and CO2 in India in their study. The conclusion reached by the authors was that fossil fuels not only contribute to economic growth but also result in significant CO2 emissions. And as a result, the surface Temperature may rise by 0.0008 percent year by 2020, with the CO2 level rising to 1.5 times that of 2008. Similarly, employing Temperature sensitivity, Y. Chen et al. (2014) investigated the impact of CO2 emission on Temperature growth. Furthermore, the findings showed that between 1990 and 2010, CO2 emissions were accountable for 50.2% of the increase in global Temperature. This suggests that CO2 emissions are a major contributor to global warming. Lastly, using a simple climate model, Ekwurzel et al. (2017) investigated the relationship between CO2 emissions, surface Temperature, and sea level. The authors calculated that approximately 57% of the observed increase in atmospheric CO2 and 42-45% of the rise in global mean surface temperature were caused by emissions linked to 90 carbon producers.

3. MODEL AND DATA SET

We obtained the 1970–2021 time series of CO2 emissions (metric tons per capita) from Global Carbon Budget (2023) – with major processing by Our World in Data, the FDI, net inflow (percentage of GDP) series from the World Bank online database and, Temperature change on land data from The Food and Agriculture Organization (FAO) for estimating the Temperature rise over the same time period. The variables that represent changes in temperature (TEMP), foreign direct investment (FDI), and total CO2 emissions (lnCO2) are correspondingly named. A natural logarithm was applied to minimize fluctuations in CO2 data. Each series was sourced from a separate data source since FDI data can be found on the World Bank, while FAOSTAT provided data on land Temperature change and Our World provided net CO2 emissions. Considering the discussion from before, this paper follows a panel causality analysis to test the PHH hypothesis by examining the relationship between FDI and CO2 emissions and later examines whether FDI and CO2 cause the Temperature rise in the Fragile Five countries.

3.1 Cross Section Dependence Tests

Table 1: Cross Section Dependence Tests

Constant Model	TEMP		FDI		lnCO2	
	Statistic	p-value	Statistic	p-value	Statistic	p-value
CD_{lm} (BP,(1980)	76.329	0.00[a]	38.225	0.00[a]	37.280	0.00[a]
CD_{lm} (Pesaran, (2004))	14.832	0.00[a]	6.311	0.00[a]	6.100	0.00[a]
CD (Pesaran, (2004))	-3.350	0.00[a]	-5.245	0.00[a]	-5.200	0.00[a]
LM_{adj} (PUY, (2008))	-0.331	0.63	3.321	0.00[a]	3.383	0.00[a]

Note: $\Delta y_{i,t} = d_i + \delta_i y_{i,t-1} + \sum_{j=1}^{p_i} \lambda_{i,j} \Delta y_{i,t-j} + u_{i,t}$ In the model, the number of lags (p_i) is taken as 1. a p<0.01, b<0.05, c<0.1.

Clearly, according to all test results, FDI and lnCO2 variables have cross-section dependence. Only the TEMP variable does not have cross-section dependence on the LM_{adj} test. However, the other test results provide evidence to support the opposite.

3.2 Panel Unit Root Test with Sharp and Smooth Breaks

The economic structures of numerous countries have altered dramatically over the last several decades, which may have an impact on the trajectory of CO2 emissions and FDI inflow in the developing economies (Uğur, 2022). The CO2 and FDI emission series' sharp breaks are largely captured by earlier research. Nonetheless, the breaks typically include both the smooth and sharp types. Enders and Lee (2012) propose that because economies differ in terms of their structure, there are also smooth breaks in economies. In order to effectively approximate the structural breaks in the series, the authors suggest a unit root test using the Fourier function. In the same way, a panel unit root test with both smooth and sharp breaks is proposed by Bahmani-Oskooee et al. (2014). The time-varying intercepts provided by the Bahmani-Oskooee et al. technique may better fit the trajectory of the economic indicators under investigation.

In the Fourier panel unit root test, Bahmani-Oskooee et al. (2014) have added harp and smooth breaks to the Fourier equations. The variables in this equation are time (t), sample size (T), sharp break time (mi), and dummy variable (DU).

$$y_{i,t} = a_i + \sum_{l=1}^{m_i} \theta_{i,1} DU_{i,1,t} + \gamma_{1,k} \sin\left(\frac{2\pi kt}{T}\right) + \gamma_{2,k} \cos\left(\frac{2\pi kt}{T}\right) + u_{i,t}$$

And using the equation below, the model is estimated. Break dates are shown by TB, whereas DU denotes a dummy variable.

$$DU_{i,1,t} = \begin{cases} 1, & \text{if } t > TB_l^i \\ 0, & \text{otherwise} \end{cases}$$

The LM test statistic is derived following the application of Newey- West to estimate the long-term variance. Then the F test statistic is found.

Table 2: Bahmani-Oskooee et al. (2014) Panel Unit Root Test with Sharp and Smooth Breaks

Panel A. TEMP					
Countries	Optimal k	Barlett	10%	5%	1%
Brazil	1	32.2831[a]	2.5189	3.4894	5.2220
India	2	2.2225[c]	2.1526	2.9482	3.7740
Indonesia	3	3.9207[b]	3.1952	3.7133	5.1046
South Africa	2	8.5846[a]	2.1526	2.9482	3.7740
Türkiye	1	5.8595[b]	2.2444	3.0611	6.3760
Panel B. lnCO2					
Brazil	3	57.1057[a]	2.2195	3.0563	4.3195
India	3	36.9783[a]	2.2148	2.9040	4.2070
Indonesia	3	37.0088[a]	2.2887	2.9662	3.9486
South Africa	2	32.0624[a]	1.9621	2.3038	3.1469
Türkiye	3	26.3978[a]	2.2376	3.0478	3.9986
Panel C. FDI					
Brazil	3	11.1474[a]	2.2135	3.1042	3.8254
India	3	2.8558[c]	2.2781	2.8995	4.1794
Indonesia	1	26.8898[a]	2.1143	3.6217	4.1660
South Africa	2	3.7080[a]	2.5596	2.9463	5.6530
Türkiye	2	0.5363	2.7411	3.8122	6.3111

Note: p<0.01 a, p<0.05 b and c<0.1

According to the unit root test results developed by Bahmani-Oskooee et al. (2014), TEMP variable is affected by unit root in all countries. In terms of optimal frequency, Indonesia has the highest frequency value and Brazil and Turkey have the lowest frequency values. A similar situation is also valid for lnCO2. The null hypothesis of a unit root cannot be rejected at the 1% significance level in all countries in the panel. In the FDI variable, only the Turkish economy does not have a unit root problem.

Frequency values show the cyclical behavior of each country's air temperature data and help us to understand the long-term nature of changes in air temperature across countries. Frequency values reveal the frequency of non-linear and periodic trends in temperature. These frequency values help us to reveal the cyclical fluctuations and environmental factors inherent in the temperature changes of countries and to reveal the impact of environmental interactions of climate policies. A frequency value of 1 in Brazil and Turkey indicates that periodic fluctuations in temperature may occur once a year (seasonal cycles) and that temperature changes generally have a cyclical structure of one year (Doğan & Kan, 2019; Serrano et al., 2024). In India and South Africa, the frequency value is 2. This number indicates that temperature changes have a periodic structure that repeats twice a year. The frequency value of 3 for Indonesia indicates that the temperature undergoes a cyclical change three times a year, indicating that there are more frequent and complex seasonal patterns related to the equatorial climate and temperature changes. The frequencies obtained in carbon emissions provide important clues in

analyzing the carbon emission trends of each country and can be used in shaping the emission policies, economic activities and climate strategies of economies. The frequency value of 3 in Brazil indicates that economic activities (such as industrial and agricultural production, deforestation) can lead to frequent and significant fluctuations in carbon emissions (Haseeb et al., 2017) The frequency value of 3 in Turkey, Indonesia and India indicates that seasonal economic activities (such as strong energy demand in summer, differentiated energy use in winter, fluctuations in energy prices) have significant impacts on carbon emissions (Alper et al., 2023). In South Africa, the frequency value of 2 indicates that carbon emissions occur cyclically twice a year. The reason for this cyclicality is carbon emissions and seasonal changes in energy consumption due to the dependence of the South African economy on the energy sector and coal consumption (Adebayo & Odugbesan, 2021). The frequency value of FDI in the Brazilian economy is 3. This ratio shows that FDI in the Brazilian economy may fluctuate periodically three times a year at certain intervals. The frequency value of 3 in the Indian economy may be due to uncertainties in financial markets and uncertainties in monetary and fiscal policies (Singhania & Gupta, 2011) The frequency value of 2 in Turkey and South Africa can be explained by Turkey's dependence on commodity imports, geopolitical position and deviations in international relations Haug & Ucal (2019) and South Africa's dependence on commodity exports, political uncertainties periodically changing investor perception (Yilanci, Ozgur, et al., 2019).

When the fourier plots of TEMP variable are analyzed, it is seen that the increase in temperature in all countries is in an increasing trend with structural breaks. This situation prevents the fitting of the fourier functions to the raw data. Moreover, except for Turkey, the fourier functions contain question marks that the temperature increase will continue. In the CO2 variable, both the raw data and the fourier functions are in a linear trend in the countries in the panel. However, the long fourier wavelengths prevent carbon emissions from following a certain path. In the post-2015 period, the continuation of the fourier functions with a negative slope indicates that the effects of the policies implemented to reduce carbon emissions have emerged. Among the three variables included in the analysis, the most consistent variable with the fourier functions is FDI. However, trend distortions in Brazil between 1995-2003, India between 2005-2010, Indonesia between 1995-2005 and Turkey between 2005-2011 cause the wavelengths of the fourier functions to lengthen. The fourier functions for Brazil, Indonesia and Turkey show that FDI has entered a downward trend.

By including Fourier functions into the panel causality test, Yılancı and Görüş (2020) propose the panel Fourier causality test. The following is the two-variable panel Fourier vector autoregression model that incorporates Fourier functions.

$$y_{i,t} = \mu_i + \sum_{j=1}^{k_i} A_{11} y_{i,t-j} + \sum_{j=1}^{k_i} A_{12} x_{i,t-j} + A_{13} \sin\left(\frac{2\pi t f_i}{T}\right) + A_{14} \cos\left(\frac{2\pi t f_i}{T}\right) + u_{i,t}$$

$$x_{i,t} = \mu_i + \sum_{j=1}^{k_i} A_{21} y_{i,t-j} + \sum_{j=1}^{k_i} A_{22} x_{i,t-j} + A_{23} \sin\left(\frac{2\pi t f_i}{T}\right) + A_{24} \cos\left(\frac{2\pi t f_i}{T}\right) + u_{i,t}$$

The null hypothesis states that there is no causation in the following equation, $\sum_{j=1}^{k_i} A_{12} x_{i,t-j}$=0, where fi is the fourier function's frequency number. The F test is used to the independent variable's delays in test statistics.

Figure 2: Fourier Graphs of TEMP, CO2, FDI

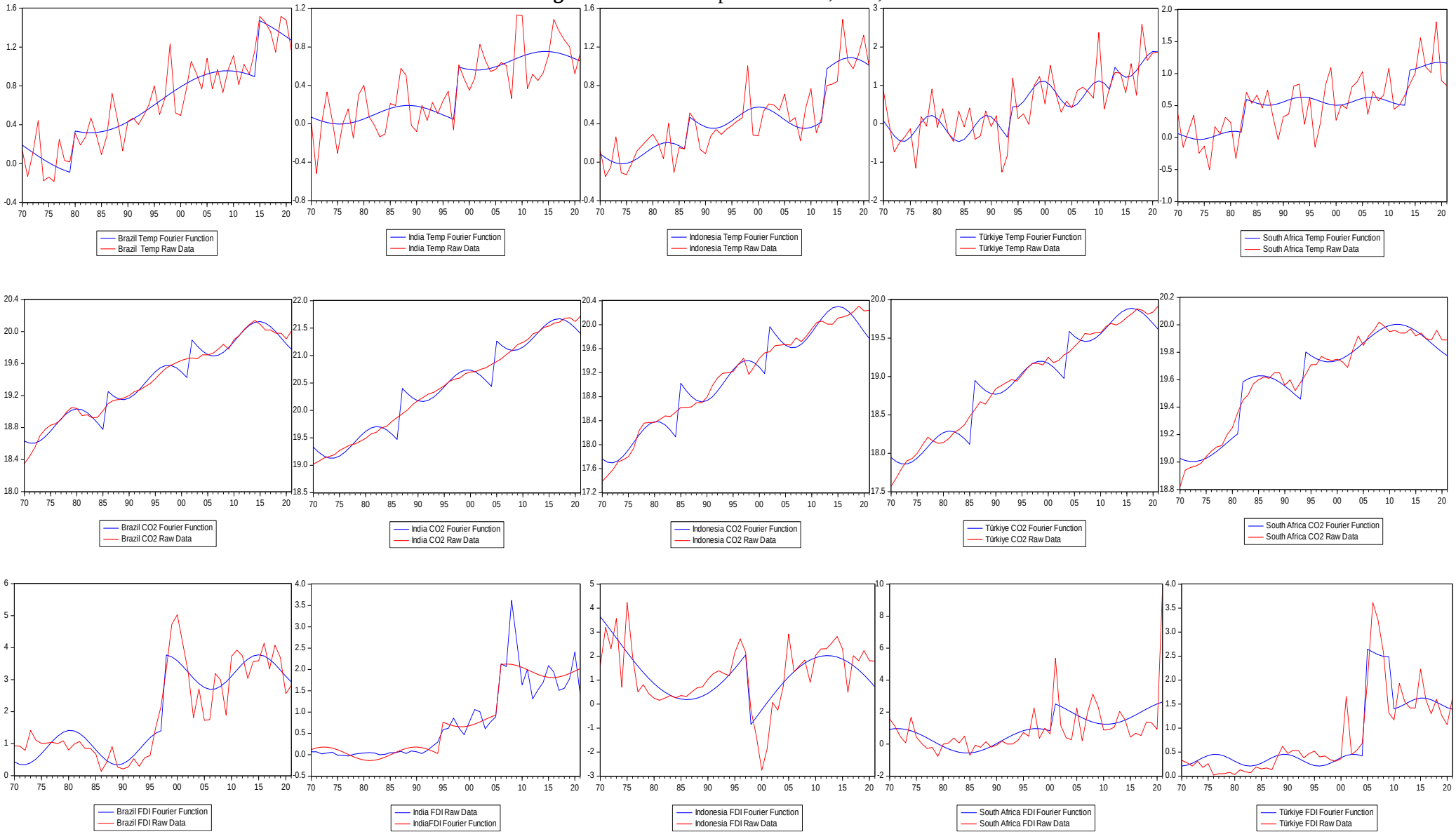


Table 3: Panel Fourier Granger Causality Test

			lnCO2 ≠>FDI	FDI≠>lnCO2			TEMP ≠>lnCO2	lnCO2≠>TEMP
Countries	Lag	k	Wald (Prob)	Wald (Prob)	lag	k	Wald(prob)	Wald(prob)
Brazil	2	2	0.284 (0.868)	5.572 (0.062) [c]	2	3	1.459 (0.482)	11.107 (0.00) [a]
India	2	2	0.373 (0.830)	7.652 (0.022) [b]	2	1	33.827 (0.00) [a]	38.288 (0.00) [a]
Indonesia	3	3	3.256 (0.196)	9.450 (0.00) [a]	2	3	7.257 (0.027) [b]	15.485 (0.00) [a]
South Africa	2	2	2.182 (0.336)	4.769 (0.092) [c]	2	2	1.914 (0.384)	16.260 (0.00) [a]
Türkiye	1	1	6.036 (0.014) [b]	7.957 (0.00) [a]	2	2	1.467 (0.48)	8.926 (0.012) [b]
Panel			0.738 (0.461)	6.223 (0.00) [a]			9.185 (0.00) [a]	18.013 (0.00) [a]

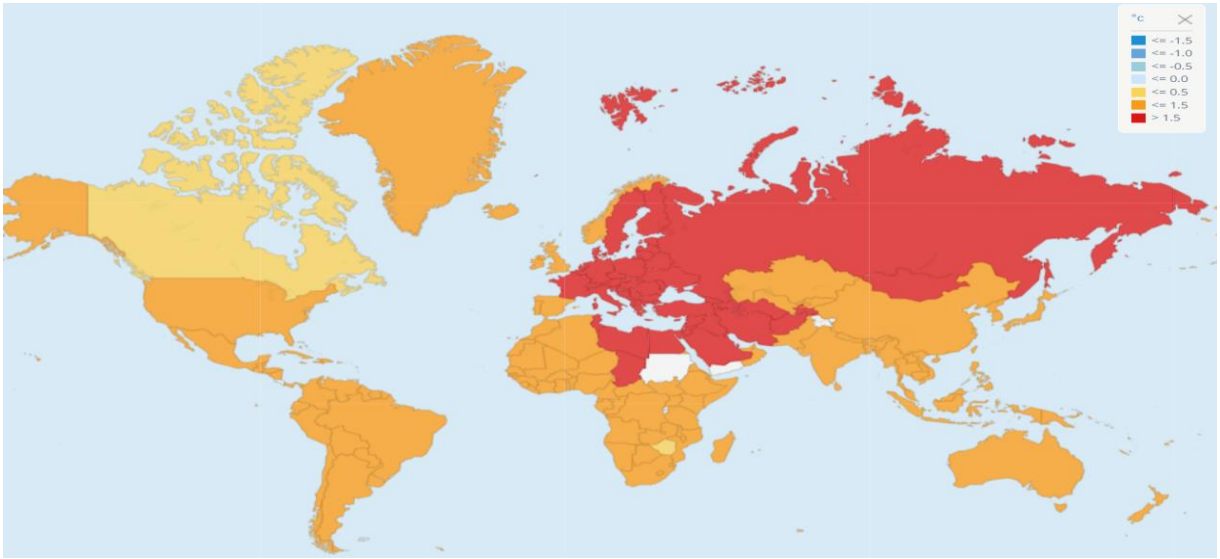
Note: p<0.01 a, p<0.05 b and c<0.1

There is Granger causality from LNCO2 to FDI only in Turkey at 5% significance level. On the contrary, there is Granger causality from FDI to lnCO2 in all countries in the panel. Accordingly, there is a reciprocal causality relationship between FDI and lnCO2 only in Turkey. The fact that the lag length and the optimal frequency length are low in the Turkish economy leads to the conclusion that carbon emissions and FDI have an effect in a shorter period and within a narrow band than expected. On the other hand, the fact that both the wave and lag lengths are high in Indonesia indicates that the effect of regulations on FDI on carbon emissions emerges with a lag.

There is Granger causality from TEMP to lnCO2 in India and Indonesia at 1% and 5% significance level, respectively. There is Granger causality from lnCO2 to TEMP in all countries. Thus, there is a reciprocal causality relationship between TEMP and lnCO2 in India and Indonesia. In Indonesia, which has high frequencies and lag lengths, the impact of policies to improve environmental quality takes a long time but is effective. Considering the frequency values, there is a suspicion that the institutional structure in Brazil and Indonesia does not support policies to improve environmental quality sufficiently.

Although the TEMP data used to measure temperature change does not show the temperature increase in each country cumulatively (in the form of a trend), the average temperature increase in the countries subject to the research was 1.5-2 °C during the time period examined in Figure 3.

Figure 3: Temperature Changes (1970-2021)



Source: FAOSTAT (2024)

4. DISCUSSION

According to empirical data, FDI inflows significantly and pollutes all five of the Fragile Five countries, which might be linked to the high levels of carbon emissions in these countries. Nonetheless, governments may choose to overlook environmental issues because of financial

limitations if foreign investment flows the country and the economy expands. According to results, it appears that the PHH is valid in the Fragile Five countries. Our findings indicate certain parallels with Wen et al. (2022), Apergis et al. (2023) and Chaudhry et al. (2022) for India, Brazil and South Africa, and with Seker et al. (2015) and Bulut et al. (2021) for Türkiye.

On the other hand, because FDIs are advantageous to the host country, they can have a favorable impact on the country's growth process. Numerous studies demonstrate that f FDI benefits the environment by introducing new technology and eco-friendly industrial methods to the host country, as opposed to raising CO2 emissions. While Mert and Caglar (2020) demonstrate that FDI has positive impact on environment for Türkiye, Shao et al. Shao et al. (2019) revealed that FDI flow to BRICS countries has increased the environmental quality. Compared to these studies, this study falls apart.

Concerns over increasing temperatures is the subject of several investigations nowadays. These factors are mostly related to CO2 emissions by describing several worldwide consequences. Although not the primary cause, rising CO2 emissions are one of the main ones contributing to the temperature increase in the atmosphere. In parallel with the studies Y. Chen et al. (2014), X. Chen & Fang (2024), Ekwurzel et al. (2017), our study concluded that CO2 emission causes temperature rise in selected countries.

5. CONCLUSION AND POLICY IMPLICATIONS

The "Fragile Five" countries require significant foreign investment due to their financial deficiencies in terms of economic growth and development. In response, these countries have implemented policies aimed at attracting FDI. However, environmental concerns are often ignored when implementing these policies. Thus, even if FDI might benefit the host country economically and financially, it can also have negative environmental effects.

In this study, we offer fresh evidence of the relationship between economic activity and climate change from the standpoint of FDI, which advances our knowledge of the mechanisms by which economic activity influences temperature increases. Although it is a commonly researched topic in the literature that FDI to developing countries results in ED and an increase in the host country's overall CO2 emissions, assessments of the impact of CO2 emissions on temperature change are limited. Using CO2 emissions as a point of reference, we empirically examine in this study how FDIs affect climate change in Fragile Five countries. We further tested the Pollution Haven and Pollution Halo hypothesis in these countries.

The Panel Fourier Granger Causality Test is used in this work to investigate the correlation between FDI inflow and carbon dioxide emissions, as well as the relationship between temperature variations and CO2 emissions, in the "Fragile Five" countries between 1970 and 2021. The findings indicate that in these nations, there is a causal relationship between FDI and both CO2 and temperature variations. Additionally, in certain nations, the results validate the PHH thesis.

The Fragile Five countries face significant challenges in addressing climate change due to their heavy reliance on FDI. While FDI's effects on the environment are considered, investments' contribution to economic growth is typically given priority. Climate change and rising temperatures, however, are detrimental to many industries, particularly the food and agriculture industries. Fragile Five countries that are highly desirable for FDIs have the potential to mitigate the long-term negative effects of FDIs by implementing policies and regulations that lessen the environmental impact of foreign investments.

To attract FDI while ensuring environmental sustainability, countries should implement stricter ER, introduce environmental taxes and incentives for green investments, facilitate green technology transfer, and create special investment zones with pre-prepared green infrastructure. In addition, monitoring and accountability mechanisms should be developed to regularly monitor and transparently report on the environmental impact of investment projects. These measures can enable sustainable development by supporting economic growth and ensuring environmental protection.

There are several limitations to our study that serve as a basis for more investigation for further research. Initially, our research has been limited to the analysis of how FDI affects CO2

emissions and temperature changes in the home country by using the temperature change in land data. Long-term cointegration of the variables was impossible to observe since this data set displays the difference between temperature changes rather than the yearly average temperatures. Furthermore, temperature change and ED were solely examined using the CO2 emission variable. While it is one of the primary causes of rising temperatures and ED, the CO2 emission variable is not the only one. Several factors may be used in future research to assess these impacts.

Etik Beyan: *Bu çalışmada "Etik Kurul" izini alınmasını gerektiren bir yöntem kullanılmamıştır.*
Yazar Katkı Beyanı*:1. Yazarın katkı oranı %35, 2. Yazarın katkı oranı ise %35, 3. Yazarın katkı oranı ise %30'dur.*
Çıkar Beyanı*: Yazarlar arasında çıkar çatışması yoktur.*

Ethics Statement: *In this study, no method requiring the permission of the "Ethics Committee" was used.*
Author Contributions Statement: *1st author's contribution rate is 35%, 2nd author's contribution rate is 35%, 3rdt author's contribution rate is 30%,*
Conflict of Interest**:** *There is no conflict of interest among the authors.*

REFERENCES

Adebayo, T. S., & Odugbesan, J. A. (2021). Modeling CO 2 emissions in South Africa: empirical evidence from ARDL based bounds and wavelet coherence techniques. *Environmental Science and Pollution Research*, *28*, 9377–9389. https://doi.org/10.1007/s11356-020-11442-3/Published

Akbostanci, E., Tunç, G. I., & Türüt-Aşik, S. (2007). Pollution haven hypothesis and the role of dirty industries in Turkey's exports. *Environment and Development Economics*, *12*(2), 297–322. https://doi.org/10.1017/S1355770X06003512

Alper, A. E., Alper, F. O., Cil, A. B., Iscan, E., & Eren, A. A. (2023). Stochastic convergence of ecological footprint: new insights from a unit root test based on smooth transitions and nonlinear adjustment. *Environmental Science and Pollution Research*, *30*(8), 22100–22114. https://doi.org/10.1007/s11356-022-23763-6

An, H., Razzaq, A., Haseeb, M., & W Mihardjo, L. W. (n.d.). *The role of technology innovation and people's connectivity in testing environmental Kuznets curve and pollution heaven hypotheses across the Belt and Road host countries: new evidence from Method of Moments Quantile Regression*. https://doi.org/10.1007/s11356-020-10775-3/Published

Apergis, N., Pinar, M., & Unlu, E. (2023). How do foreign direct investment flows affect carbon emissions in BRICS countries? Revisiting the pollution haven hypothesis using bilateral FDI flows from OECD to BRICS countries. *Environmental Science and Pollution Research*, *30*(6), 14680–14692. https://doi.org/10.1007/s11356-022-23185-4

Bağlıtaş, H. H., & Yaprak Öztürk, Z. (2019). An Empirical Analysis of Fragile Five In The Context of The Pollution Haven Hypothesis. In S. Coban, S. W. Dalpour, C. Marangoz, & E. Bulut (Eds.), *Recent Economic Approaches and Financial Corporate Policy* (pp. 71–94). IJOPEC Publication.

Bahmani-Oskooee, M., Chang, T., & Wu, T. (2014). Revisiting purchasing power parity in African countries: Panel stationary test with sharp and smooth breaks. *Applied Financial Economics*, *24*(22), 1429–1438. https://doi.org/10.1080/09603107.2014.925068

Bakhsh, K., Rose, S., Ali, M. F., Ahmad, N., & Shahbaz, M. (2017). Economic growth, CO2 emissions, renewable waste and FDI relation in Pakistan: New evidences from 3SLS. *Journal of Environmental Management*, *196*, 627–632. https://doi.org/10.1016/j.jenvman.2017.03.029

Bakirtas, I., & Cetin, M. A. (2017). Revisiting the environmental Kuznets curve and pollution haven hypotheses: MIKTA sample. *Environmental Science and Pollution Research*, *24*(22), 18273–18283. https://doi.org/10.1007/s11356-017-9462-y

Balsalobre-Lorente, D., Gokmenoglu, K. K., Taspinar, N., & Cantos-Cantos, J. M. (2019). An approach to the pollution haven and pollution halo hypotheses in MINT countries. *Environmental Science and Pollution Research*, *26*(22), 23010–23026. https://doi.org/10.1007/s11356-019-05446-x

Breusch, T. S., & Pagan, A. R. (1980). The Lagrange Multiplier Test and its Applications to Model Specification in Econometrics. *The Review of Economic Studies*, *47*(1), 239–253. https://about.jstor.org/terms

Bulut, U., Ucler, G., & Inglesi-Lotz, R. (2021). Does the pollution haven hypothesis prevail in Turkey? Empirical evidence from nonlinear smooth transition models. *Environmental Science and Pollution Research*, *28*, 38563. https://doi.org/10.1007/s11356-021-13476-7/Published

Chadwick, M. G. (2018). *Dependence of "Fragile Five" and "Troubled Ten" Emerging Markets' Financial System to US Monetary Policy and Monetary Policy Uncertainty* (17/18).

Chandrika, R., Mahesh, R., & Tripathy, N. (2022). Is India a pollution haven? Evidence from cross-border mergers and acquisitions. *Journal of Cleaner Production*, *376*. https://doi.org/10.1016/j.jclepro.2022.134355

Chaudhry, I. S., Yin, W., Syed, &, Ali, A., Faheem, M., Abbas, Q., Farooq, F., & Rahman, S. U. (2022). Moderating role of institutional quality in validation of pollution haven hypothesis in BRICS: a new evidence by using DCCE approach. *Environmental Science and Pollution Research*, *29*, 9193–9202. https://doi.org/10.1007/s11356-021-16087-4/Published

Chen, X., & Fang, T. (2024). Temperature anomalies and foreign direct investment: City-level evidence from China. *International Review of Financial Analysis*, *91*. https://doi.org/10.1016/j.irfa.2023.102983

Chen, Y., Li, B., Li, Z., & Shi, X. (2014a). Quantitatively evaluating the effects of CO2 emission on temperature rise. *Quaternary International*, *336*, 171–175. https://doi.org/10.1016/j.quaint.2013.11.031

Chen, Y., Li, B., Li, Z., & Shi, X. (2014b). Quantitatively evaluating the effects of CO2 emission on temperature rise. *Quaternary International*, *336*, 171–175. https://doi.org/10.1016/j.quaint.2013.11.031

Cole, M. A. (2004a). Trade, the pollution haven hypothesis and the environmental Kuznets curve: Examining the linkages. *Ecological Economics*, *48*(1), 71–81. https://doi.org/10.1016/j.ecolecon.2003.09.007

Cole, M. A. (2004b). Trade, the pollution haven hypothesis and the environmental Kuznets curve: Examining the linkages. *Ecological Economics*, *48*(1), 71–81. https://doi.org/10.1016/j.ecolecon.2003.09.007

Das, D., Srinivasan, R., & Sharfuddin, A. (2011). Fossil fuel consumption, carbon emissions and temperature variation in India. *Energy and Environment*, *22*(6), 695–709. https://doi.org/10.1260/0958-305X.22.6.695

Doğan, H. G., & Kan, A. (2019). The effect of precipitation and temperature on wheat yield in Turkey: a panel FMOLS and panel VECM approach. *Environment, Development and Sustainability*, *21*(1), 447–460. https://doi.org/10.1007/s10668-018-0298-5

Ekwurzel, B., Boneham, J., Dalton, M. W., Heede, R., Mera, R. J., Allen, M. R., & Frumhoff, P. C. (2017). The rise in global atmospheric CO2, surface temperature, and sea level from emissions traced to major carbon producers. *Climatic Change*, *144*(4), 579–590. https://doi.org/10.1007/s10584-017-1978-0

Enders, W., & Lee, J. (2012). A unit root test using a fourier series to approximate smooth breaks. *Oxford Bulletin of Economics and Statistics*, *74*(4), 574–599. https://doi.org/10.1111/j.1468-0084.2011.00662.x

Eskeland, G. S., & Harrison, A. E. (2003). Moving to greener pastures? Multinationals and the pollution haven hypothesis. *Journal of Development Economics*, *70*, 1–23. www.elsevier.com/locate/econbase

Fakta o klimatu. (2024, March 1). *How are CO_2 concentrations related to warming?* Fakta o Klimatu. https://factsonclimate.org/infographics/concentration-warming-relationship#:~:text=More%20specifically%3A%20every%20time%20the,increases%20by%200.1%20%C2%B0C.

Fang, J. Y., Zhu, J. L., Wang, S. P., Yue, C., & Shen, H. H. (2011). Global warming, human-induced carbon emissions, and their uncertainties. In *Science China Earth Sciences* (Vol. 54, Issue 10, pp. 1458–1468). https://doi.org/10.1007/s11430-011-4292-0

FAOSTAT. (2024). *FAOSTAT*. https://www.fao.org/faostat/en/#data/ET

Global Carbon Budget. (2023). *Global Carbon Budget (2023) – with major processing by Our World in Data. "Annual CO_2 emissions – GCB" [dataset]. Global Carbon Project, "Global Carbon Budget" [original data]*.

Goklany, I. M. (2009). IS CLIMATE CHANGE THE "DEFINING CHALLENGE OF OUR AGE"? In *Environment* (Vol. 20, Issue 3).

Haseeb, M., Hassan, S., & Azam, M. (2017). Rural–urban transformation, energy consumption, economic growth, and CO2 emissions using STRIPAT model for BRICS countries. *Environmental Progress and Sustainable Energy*, *36*(2), 523–531. https://doi.org/10.1002/ep.12461

Haug, A. A., & Ucal, M. (2019). The role of trade and FDI for CO2 emissions in Turkey: Nonlinear relationships. *Energy Economics*, *81*, 297–307. https://doi.org/10.1016/j.eneco.2019.04.006

He, J. (2006). Pollution haven hypothesis and environmental impacts of foreign direct investment: The case of industrial emission of sulfur dioxide (SO 2) in Chinese provinces. *Ecological Economics*, *60*, 228–245. https://doi.org/10.1016/j.eco

Hoffmann, R., Lee, C. G., Ramasamy, B., & Yeung, M. (2005). FDI and pollution: A Granger causality test using panel data. *Journal of International Development*, *17*(3), 311–317. https://doi.org/10.1002/jid.1196

IPCC. (2007). *The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*.

Islam, M. M., Kamran Khan, M., Tareque, M., Jehan, N., Dagar, V., Muhammad, *, & Khan, K. (2021). Impact of globalization, foreign direct investment, and energy consumption on CO 2 emissions in Bangladesh: Does institutional quality matter? *Environmental Science and Pollution Research*, *28*, 48851–48871. https://doi.org/10.1007/s11356-021-13441-4/Published

Kearsley, A., & Riddel, M. (2010). A further inquiry into the Pollution Haven Hypothesis and the Environmental Kuznets Curve. *Ecological Economics*, *69*(4), 905–919. https://doi.org/10.1016/j.ecolecon.2009.11.014

Khan, M. A., & Ozturk, I. (2020). Examining foreign direct investment and environmental pollution linkage in Asia. *Environmental Science and Pollution Research*, *27*(7), 7244–7255. https://doi.org/10.1007/s11356-019-07387-x

Kivyiro, P., & Arminen, H. (2014). Carbon dioxide emissions, energy consumption, economic growth, and foreign direct investment: Causality analysis for Sub-Saharan Africa. *Energy*, *74*(C), 595–606. https://doi.org/10.1016/j.energy.2014.07.025

Lee, J. W. (2013). The contribution of foreign direct investment to clean energy use, carbon emissions and economic growth. *Energy Policy*, *55*, 483–489. https://doi.org/10.1016/j.enpol.2012.12.039

Liang, F. (2008). Does Foreign Direct Investment Harm the Host Country's Environment? Evidence from China. *Current Topics in Management*, 105–121.

http://ssrn.com/abstract=1479864Electroniccopyavailableat:https://ssrn.com/abstract=1479864Electroniccopyavailableat:http://ssrn.com/abstract=1479864

Mabey, N., & McNally, R. (1998). *Foreign Direct Investment and the Environment: From Pollution Havens to Sustainable Development: a WWF-UK Report*.

Menegaki, A. N., & Ozturk, I. (2016). Renewable energy, rents and GDP growth in MENA countries. *Energy Sources, Part B: Economics, Planning and Policy*, *11*(9), 824–829. https://doi.org/10.1080/15567249.2014.949392

Mert, M., & Caglar, A. E. (2020). Testing pollution haven and pollution halo hypotheses for Turkey: a new perspective. *Environmental Science and Pollution Research*, *27*, 32933–32943. https://doi.org/10.1007/s11356-020-09469-7/Published

Murota, Y., & Ito, K. (1996). Global warming and developing countries The possibility of a solution by accelerating development. In *Energy Policy* (Vol. 24, Issue 12).

Pao, H. T., & Tsai, C. M. (2011). Multivariate Granger causality between CO2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): Evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries. *Energy*, *36*(1), 685–693. https://doi.org/10.1016/j.energy.2010.09.041

Pesaran, M. H. (2004). *General Diagnostic Tests for Cross Section Dependence in Panels* (Discussion Paper No. 1240).

Pesaran, M. H., Ullah, A., & Yamagata, T. (2008). A bias-adjusted LM test of error cross-section independence. *Econometrics Journal*, *11*(1), 105–127. https://doi.org/10.1111/j.1368-423X.2007.00227.x

Poelhekke, S., & Van der Ploeg, F. (2015). Green havens and pollution havens. *World Economy*, *38*(7), 1159–1178. https://doi.org/10.1111/twec.12219

Seker, F., Ertugrul, H. M., & Cetin, M. (2015). The impact of foreign direct investment on environmental quality: A bounds testing and causality analysis for Turkey. In *Renewable and Sustainable Energy Reviews* (Vol. 52, pp. 347–356). Elsevier Ltd. https://doi.org/10.1016/j.rser.2015.07.118

Serrano, A. L. M., Rodrigues, G. A. P., Martins, P. H. dos S., Saiki, G. M., Filho, G. P. R., Gonçalves, V. P., & Albuquerque, R. de O. (2024). Statistical Comparison of Time Series Models for Forecasting Brazilian Monthly Energy Demand Using Economic, Industrial, and Climatic Exogenous Variables. *Applied Sciences (Switzerland)*, *14*(13). https://doi.org/10.3390/app14135846

Shahbaz, M., Ozturk, I., Afza, T., & Ali, A. (2013). Revisiting the environmental Kuznets curve in a global economy. In *Renewable and Sustainable Energy Reviews* (Vol. 25, pp. 494–502). Elsevier Ltd. https://doi.org/10.1016/j.rser.2013.05.021

Shao, Q., Wang, X., Zhou, Q., & Balogh, L. (2019). Pollution haven hypothesis revisited: A comparison of the BRICS and MINT countries based on VECM approach. *Journal of Cleaner Production*, *227*, 724–738. https://doi.org/10.1016/j.jclepro.2019.04.206

Sharma, S., Bhattacharya, S., & Garg, A. (2006). Greenhouse gas emissions from India: A perspective. *Current Science*, *90*(3), 326–333. http://www.rivm

Singhania, M., & Gupta, A. (2011). Determinants of foreign direct investment in India. *Journal of International Trade Law and Policy*, *10*(1), 64–82. https://doi.org/10.1108/14770021111116142

Singhania, M., & Saini, N. (2021). Demystifying pollution haven hypothesis: Role of FDI. *Journal of Business Research*, *123*, 516–528. https://doi.org/10.1016/j.jbusres.2020.10.007

Sun, C., Zhang, F., & Xu, M. (2017). Investigation of pollution haven hypothesis for China: An ARDL approach with breakpoint unit root tests. *Journal of Cleaner Production*, *161*, 153–164. https://doi.org/10.1016/j.jclepro.2017.05.119

Tang, C. F., & Tan, B. W. (2015). The impact of energy consumption, income and foreign direct investment on carbon dioxide emissions in Vietnam. *Energy*, *79*(C), 447–454. https://doi.org/10.1016/j.energy.2014.11.033

Terzi, H., & Pata, U. K. (2020). Is the pollution haven hypothesis (PHH) valid for Turkey? *Panoeconomicus*, *67*(1), 93–109. https://doi.org/10.2298/PAN161229016T

Uğur, M. S. (2022). The relationship between foreign direct investment, economic growth, energy consumption and CO2 emissions: Evidence from ARDL model with a structural break for Turkey. *Ege Akademik Bakis (Ege Academic Review)*, *22*(3), 44–55. https://doi.org/10.21121/eab.1100759

Van Den Bulcke, D., & Zhang, H. (1998). Foreign Equity Joint Ventures in China: Interactions between Government Policies and Multinational Investment Strategies . In *International Trade, Foreign Direct Investment and the Economic Environment*. Palgrave Macmillan.

Waldkirch, A., & Gopinath, M. (2008). Pollution control and foreign direct investment in Mexico: An industry-level analysis. *Environmental and Resource Economics*, *41*(3), 289–313. https://doi.org/10.1007/s10640-008-9192-1

Wen, Y., Haseeb, M., Safdar, N., Yasmin, F., Timsal, S., & Li, Z. (2022). Does Degree of Stringency Matter? Revisiting the Pollution Haven Hypothesis in BRICS Countries. *Frontiers in Environmental Science*, *10*. https://doi.org/10.3389/fenvs.2022.949007

Yilanci, V., Cutcu, I., Cayir, B., & Saglam, M. S. (2023). Pollution haven or pollution halo in the fishing footprint: Evidence from Indonesia. *Marine Pollution Bulletin*, *188*. https://doi.org/10.1016/j.marpolbul.2023.114626

Yilanci, V., Gorus, M. S., & Aydin, M. (2019). Are shocks to ecological footprint in OECD countries permanent or temporary? *Journal of Cleaner Production*, *212*, 270–301. https://doi.org/10.1016/j.jclepro.2018.11.299

Yilanci, V., Muhammed, &, & Gorus, S. (2020). Does economic globalization have predictive power for ecological footprint in MENA counties? A panel causality test with a Fourier function. *Environmental Science and Pollution Research*, 40552–40562. https://doi.org/10.1007/s11356-020-10092-9/Published

Yilanci, V., Ozgur, O., & Gorus, M. S. (2019). The asymmetric effects of foreign direct investment on clean energy consumption in BRICS countries: A recently introduced hidden cointegration test. *Journal of Cleaner Production*, *237*. https://doi.org/10.1016/j.jclepro.2019.117786

Zarsky, L. (1999). *Havens, Halos and Spaghetti: Untangling the Evidence about Foreign Direct Investment and the Environment*.

Zhang, C., & Zhou, X. (2016a). Does foreign direct investment lead to lower CO2 emissions? Evidence from a regional analysis in China. In *Renewable and Sustainable Energy Reviews* (Vol. 58, pp. 943–951). Elsevier Ltd. https://doi.org/10.1016/j.rser.2015.12.226

Zhang, C., & Zhou, X. (2016b). Does foreign direct investment lead to lower CO2 emissions? Evidence from a regional analysis in China. In *Renewable and Sustainable Energy Reviews* (Vol. 58, pp. 943–951). Elsevier Ltd. https://doi.org/10.1016/j.rser.2015.12.226

Zheng, H., Zhang, L., Song, W., & Mu, H. (2023). Pollution heaven or pollution halo? Assessing the role of heterogeneous environmental regulation in the impact of foreign direct investment on green economic efficiency. *Environmental Science and Pollution Research*, *30*(8), 21619–21637. https://doi.org/10.1007/s11356-022-23496-6

Zhu, H., Duan, L., Guo, Y., & Yu, K. (2016). The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: Evidence from panel quantile regression. *Economic Modelling*, *58*, 237–248. https://doi.org/10.1016/j.econmod.2016.05.003