PEK
POLITIK EKONOMIK KURAM

Research Article

The Impact of Foreign Direct Investment and R&D Expenditures on Climate Change: The Case Of BRICS-T and Selected OECD Member Countries

Kerem ÖZEN[1], Cemalettin LEVENT[2], Burak DARICI[3], Meltem İNCE YENİLMEZ[4]

[1] Dr. Independent Researcher, keremozen5@gmail.com, ORCID: 0000-0003-2264-2787
[2] Dr. Independent Researcher, Cemalettin_65_@hotmail.com, ORCID: 0000-0001-7147-1027
[3] Prof.Dr., Bandırma 17 Eylül Üniversitesi, İİBF, bdarici@bandirma.edu.tr, ORCID: 0000-0003-0765-7374
[4] Prof.Dr., Izmir Demokrasi Üniversitesi, İİBF, melteminceyenilmez@gmail.com, ORCID: 0000-0002-4689-3196

Abstract: Climate change, one of the most urgent problems of today's world, is an important issue emphasized by researchers and policymakers. Climate change, which has become a global problem, has negative consequences for the environment and people. Therefore, the main objective of this study is to investigate the impact of FDI and R&D expenditures on climate change in BRICS-T (Brazil, Russia, India, China, South Africa, Turkey) and selected OECD (United Kingdom, Italy, Canada, Spain, Portugal, Denmark, Norway, Austria, Spain, Portugal, Denmark, Norway, Australia) member countries for the period 2000-2020 using panel data analysis method. OECD and BRICS-T country groups are analyzed separately. According to the results of the analysis, there is no causality relationship between climate change and research and development variables, while there is a bidirectional causality relationship between research and development and foreign direct investment variables. When the causality relationship is analyzed for countries and variables, it is found that there is a bidirectional causality relationship between research and development and FDI variables for Russia and India, and a unidirectional causality relationship from research and development variable to FDI variable for China, South Africa and Turkey.

Keywords: FDI, R&D, CO2 Emissions, Panel Data Analysis
Jel Codes : Q50, Q54, Q58

Doğrudan Yabancı Yatırım ve AR-GE Harcamalarının İklim Değişikliği Üzerindeki Etkisi: BRICS-T ve Seçilmiş OECD Üyesi Ülkeler Örneği

Öz: Günümüz dünyasının en acil sorunlarından biri olan iklim değişikliği, araştırmacılar ve politika yapıcılar tarafından üzerinde durulan önemli bir konudur. Küresel bir sorun haline gelen iklim değişikliği, çevre ve insanlar üzerinde olumsuz sonuçlar doğurmaktadır. Bu nedenle, bu çalışmanın temel amacı, 2000-2020 dönemi için BRICS-T (Brezilya, Rusya, Hindistan, Çin, Güney Afrika, Türkiye) ve seçilmiş OECD (Birleşik Krallık, İtalya, Kanada, İspanya, Portekiz, Danimarka, Norveç, Avusturya, İspanya, Portekiz, Danimarka, Norveç, Avustralya) üyesi ülkelerde DYY ve Ar-Ge harcamalarının iklim değişikliği üzerindeki etkisini panel veri analizi yöntemiyle araştırmaktır. OECD ve BRICS-T ülke grupları ayrı ayrı analiz edilmiştir. Analiz sonuçlarına göre iklim değişikliği ile araştırma ve geliştirme değişkenleri arasında herhangi bir nedensellik ilişkisi bulunmazken, araştırma ve geliştirme ile doğrudan yabancı yatırım değişkenleri arasında çift yönlü nedensellik ilişkisi olduğu tespit edilmiştir. Nedensellik ilişkisi ülkeler ve değişkenler için incelendiğinde ise Rusya ve Hindistan için araştırma ve geliştirme ile doğrudan yabancı yatırım değişkenleri arasında çift yönlü, Çin, Güney Afrika ve Türkiye için ise araştırma ve geliştirme değişkeninden doğrudan yabancı yatırım değişkenine doğru tek yönlü bir nedensellik ilişkisi olduğu tespit edilmiştir.

Anahtar Kelimeler: DYY, AR-GE, CO2 Emisyonları, Panel Veri Analizi
Jel Kodları: Q50, Q54, Q58

Atıf: Özen K., Levent, C., Darıcı, B. and Yenilmez, M. I. (2024). The Impact of Foreign Direct Investment and R&D Expenditures on Climate Change: The Case of BRICS-T And Selected OECD Member Countries, *Politik Ekonomik Kuram, 8*(4), 1052-1062. https://doi.org/10.30586/pek.1540208

Geliş Tarihi: 28.08.2024
Kabul Tarihi: 28.10.2024

1. Introduction

Environmental degradation is one of the most serious problems of modern society. This problem attracts great attention from scientists and policymakers because it affects billions of people around the world. The role of greenhouse gas emissions in climate change is widely accepted. Carbon dioxide (CO2) accounts for more than 75% of global greenhouse gas emissions. Increasing CO2 levels have led to an increase in extreme weather events such as heat waves, floods, droughts and global climate change in recent years (Adebayo et al. 2022: 1). CO2 emissions are the main cause of today's global climate change. The problem of carbon-induced climate change has recently gained great importance for the development of the world economy. Many international organizations are making great efforts to solve this problem. In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was signed during the United Nations Conference on Environment and Development. In 1997, the UNFCCC adopted the Kyoto Protocol to balance the amount of greenhouse gases in the atmosphere (Huang et al. 2022, p. 1).

Climate change is the result of many factors, and foreign direct investment is one of these factors. Foreign direct investment is understood as the investment made by a company headquartered in one country to establish a long-term connection with another country (IMF, 1993, p. 86; Mucuk and Demirsel, 2009, p. 366). FDI is an important factor that determines how production is distributed among countries or regions in the global economic system. Ensuring the best distribution of labour, capital and technological progress among production methods is the purpose of foreign direct investment inflows and outflows. As connections between world financial markets strengthen, there have been significant increases in the volume and speed of cross-border capital flows. As a result, foreign direct investments are made with the motivation of profit and risk avoidance (Xing and Wang, 2022, p. 42).

Research and development expenditures are another important factor of climate change. These expenses relate to the development and research of new products. Research and development activities are typically overseen by specialized departments or centres of an organization; Sometimes it is outsourced to universities or government agencies. In the business world, research and development generally refers to long-term, forward-looking science and technology projects. A business's ability to develop and produce new products is critical to its survival (Dritsaki and Dritsaki, 2023, p. 2). Therefore, the main purpose of this study is to examine how foreign direct investment and R&D expenditures affect climate change in BRICS-T and some other OECD member countries using panel data analysis.

2. Review of the Literature on the Connection Between Climate Change and Foreign Direct Investment

There are many studies in literature examining the relationship between foreign direct investments and climate change. For example, Sarkodie et al (2020), in a study covering 47 countries in Sub-Saharan Africa, investigated whether foreign direct investment and renewable energy can contribute to reducing global warming. This study revealed the effects of increases in income levels, governance and use of renewable energy on climate change. For example, it is stated that an increase in the share of renewable energy can lead to a significant reduction in greenhouse gas emissions. Ssali et al. (2019) examined some countries in Sub-Saharan Africa and evaluated the relationship between energy consumption, economic growth, environmental pollution and foreign direct investment with panel data analysis. The results show that there is a unidirectional causality between foreign direct investment and CO2 emissions in the long term, but this relationship is not clear in the short term. The research conducted by Abdouli and Hammami (2017) addressed the relationship between foreign direct investment, environmental pollution and economic growth in the Middle East and North Africa. The panel data analysis results used to support the pollution haven theory, which suggests that environmental degradation increases with foreign direct investments.

Another study by Marques and Caetano (2020) discussed the relationship between foreign direct investment and carbon emissions in high and middle-income countries. The findings show that foreign direct investment can reduce carbon emissions in high-income countries but temporarily increase emissions in middle-income countries, demonstrating the accuracy of the pollution hypothesis. The study by Khan and Öztürk (2020) examined the relationship between environmental pollution and foreign direct investment in Asia. The panel data analysis used is supported by findings showing that foreign direct investments reduce environmental pollution. Finally, Usta (2023) study examining the relationship between foreign direct investment and environmental impacts in N-11 countries also contributes to the literature in this field. A study conducted in Turkey examined the relationship between economic growth, foreign direct investment and carbon emissions. The Directed Cyclic Graphs (DAGs) method used in the study showed that foreign direct investments indirectly affect carbon emissions through international trade.

Öztürk and Saygın (2020), in their study covering the period between 1974 and 2016 in Turkey, analyzed the relationship between real income per capita, trade openness, foreign direct investments and carbon emissions with the toda-Yamamoto causality test and ARDL limit test. The findings show that foreign direct investments have a positive impact on carbon emissions in Turkey, which is consistent with the Pollution Haven Hypothesis. It is associated with the increase in foreign direct investments in the economic globalization process in Turkey and the increase in CO2 emissions.

3. Review of the Literature on the Connection Between R&D Spending and Climate Change

There are many national and international studies in literature examining the relationship between R&D expenditures and climate change (Lei, Zhang and Wei, 2012). The research examined the link between CO2 emissions, foreign technical proliferation and China's energy use. The study used time series analysis to analyze data from 1960 to 2008. The results show that local R&D expenditures, global technology diffusion and technological progress reduce CO2 emissions. Additionally, it has been shown that investing in R&D can reduce CO2 emissions both directly and indirectly. The impact of financial development, economic growth and R&D expenditures on carbon emissions (Shahbaz et al., 2020). The results obtained from the use of the ARDL approach in research projects reveal that R&D expenditures reduce CO2 emissions. Churchill et al.'s (2019) study aims to investigate the relationship between R&D intensity and CO2 emissions in G7 countries between 1870 and 2014. Examination of the study's panel data shows that the relationship between R&D and CO2 emissions changes over time. However, it has been determined that research and development activities significantly reduce CO2 emissions. Behdioğlu and Çelik (2016) examined R&D expenditures and emissions in OECD countries. A study conducted using artificial neural networks and the STIRPAT model showed that R&D spending reduces emissions in OECD countries. Işık and Kılınç (2014) examined the contribution of energy-related R&D expenditures to CO2 emissions in the transportation sector. According to dynamic panel data analysis, spending on energy R&D reduces CO2 emissions. Haseeb et al (2019) examined the impact of energy consumption, environmental pollution and economic expansion on health and R&D expenditures in ASEAN countries. Research applying the ARDL methodology has shown a positive relationship between economic growth, energy consumption and environmental degradation, and health and R&D expenditures of ASEAN countries.

4. Data Set, Methodology and Analysis Findings

4.1 Material and Method

The research material consists of data on research and development (R&D) expenditure, foreign direct investment and climate change (CO2) for eight OECD and six BRICS-T countries, covering the period 2000-2020. Data for the study were obtained from the official World Bank and OECD STAT websites, and analysis was performed using the STATA 16 statistical package.

Table 1. Definition and Source of Variables

Variables	Abbreviation	Definition	Period	Method	Country group	Source
CO2 Emissions	CO2	Metric tonnes per capita	2000-2020	Panel data analysis	BRICS-T OECD	World Bank
R&D Expenditures	RD	% of GDP	2000-2020	Panel data analysis	BRICS-T OECD	OECD STAT
Foreign Direct Investment	INVEST	% of GDP	2000-2020	Panel data analysis	BRICS-T OECD	OECD STAT

Table 1 shows the definition, method and sources of the variables used for the analysis.

4.2. Horizontal Cross-Section Dependency Test

In panel data processing, there may be interactions between the units that make up the horizontal cross-section. Horizontal cross-section dependence is the term used to describe this condition. Examples of horizontal cross-section dependence include a shock that occurs in one country making up the panel data and affecting another country in the panel. In some analyses, the coefficients derived from time-based regressions will be biased if a horizontal cross-section occurs, making it impossible to produce meaningful analysis results. It is therefore best to start by examining the horizontal cross-sectional dependence between variables. Therefore, a horizontal cross-sectional study between the variables can provide better analysis results before moving on to unit root analysis (Menyah et al. 2014).

4.3. Panel Unit Root Test

An important problem that can be encountered when working with time series data is that the series is not stationary. If the series is not stationary, this relationship may appear as a spurious relationship in the model, even if there is no statistically significant relationship between the variables. This may reduce the reliability of predictions made using a non-stationary data set. Stationarity constraints play an important role in preventing the spurious regression problem (Demir, 2021; Altun, İşleyen and Görür, 2018). If time series data does not meet the requirements of stationarity tests, it may be necessary to make the series stationary by differencing. In panel data analysis, unit root tests can be used to determine whether the data is stationary. These tests are generally divided into two categories: first-generation and second-generation unit root tests. In the study, the CIPS (Crosssectionally Augmented IPS) test, which is the second-generation unit root test, is used according to the data set (Demir and Görür, 2020).

4.4. Panel Cointegration Test

Empirical studies have shown that most macroeconomic time series are non-stationary. These non-stationary series cause spurious regression problems because they contain unit roots. To solve the spurious regression problem, one of the recommended methods is to regress non-stationary series by taking the differences of these series instead. However, the different methods may lead to the loss of some information that is important for long-term balance. Because analyzes made by taking the first differences of the series can eliminate the long-term relationship between these series. Cointegration analysis is recommended to solve this problem. Cointegration is a method that tests whether there is a long-term equilibrium relationship between variables and allows to directly estimate this relationship (Pedroni, 2004). The hypotheses for cointegration tests are as follows:

H_0: There is no cointegration between the variables.
H_1: There is cointegration between variables.

Westerlund (2007) panel cointegration test, based on the error correction model used when working with panel data, aims to test the cointegration relationship between two or more variables. This test tests the existence of cointegration by determining whether each unit has its error correction. This test is an extension of the cointegration test developed for time series by Banerjee, Dolado and Mestre (1998) for panel data. The important assumption of the test is that the series is equally stationary (Demir and Görür, 2020).

5. Analysis Results for BRICS-T Countries

Table 2. Horizontal Cross-Section Dependency Test

Tests	**CO2**		**Invest**		**RD**	
CD Test	Stat	Prob	Stat	prob	Stat	prob
Cd LM1 (Bresuch, Pagan 1980)	266.591	0.001	40.130	0.001	96.068	0.001
Cd LM2 (Pesaran 2004 CDlm)	45.934	0.001	4.588	0.001	14.801	0.001
cd LM (Pesaran 2004 CD)	-3.374	0.001	-2.920	0.002	-3.006	0.001
Bias-adj. CD test	10.182	0.001	0.656	0.256	8.234	0.001

In Table 2, the horizontal cross-section results of three separate variables are given in the same table. When Table 2 is analyzed, it is determined that there is horizontal cross-section dependence in the series according to the prob values. According to the horizontal cross-section dependence result, second-generation unit root tests should be used.

Table 3. CADF/CIPS Unit Root Test

CO2				**Invest**				**RD**			
level		Difference		Level		difference		level		difference	
Lags	CADF-stat	Lags	CADF-stat	Lags	CADF-stat	Lags	CADF-stat	Lags	CADF-stat	Lags	CADF-stat
5.000	-1.496	5.000	-7.018	2.000	-1.656	5.000	-7.224	2.000	-1.687	2.000	-7.603
5.000	-1.069	5.000	-7.001	2.000	-2.327	2.000	-11.961	2.000	0.563	2.000	-8.890
5.000	-1.622	5.000	-6.469	2.000	-1.685	5.000	-8.449	2.000	2.739	2.000	-12.929
3.000	-1.357	3.000	-14.581	2.000	-1.833	5.000	-7.663	2.000	-2.040	2.000	-13.284
3.000	-1.428	3.000	-13.687	2.000	-1.862	2.000	-12.558	2.000	-1.243	2.000	-8.138
3.000	-1.969	3.000	-13.910	2.000	-1.572	2.000	-19.434	2.000	-2.152	2.000	-11.397
CIPS-stat=-1.323		CIPS-stat=-10.444		CIPS-stat=-2.823		CIPS--stat=-11.215		CIPS-stat=-1.737		CIPS-stat=-10.374	

The results of the CADF/CIPS test for each of the three independent variables are shown in Table 3. The CIPS test examines the stationarity of the panel data, while the CADF test examines the stationarity of individual countries. Evaluating the CADF results generated by the application, each country examined becomes stationary at first differences at different levels of significance. According to an analysis of the CIPS test results obtained by averaging the CADF test data, the variables become stable at first difference.

The Gengenbach, Urbain and Westerlund (GUW) (2016) panel cointegration test, which is one of the panels cointegration tests, is used to analyze whether the series have a long-run relationship after determining whether they have a unit root process.

Table 4. Panel Cointegration Analysis Results

	d.y	**Coef**	**T Bar**	**P-val***
CO_2-Invest	y(t-1)	-0.264	-1.475	>0.1
CO_2-RD	y(t-1)	-0.543	-2.056	>0.1
Invest-RD	y(t-1)	-0.799	-2.865	<=0.05

The expression obtained as a result of GUW co-integration analysis shows that there is no co-integration relationship between the variables considered. Accordingly, there is no long-run relationship between climate change and FDI variables. At the same time, there is also no long-term relationship between climate change research and development variables.

Table 5. Emir Mahmutoğlu Causality Test

		Lag	Wald St..	p-val.	Panel Fisher St.	p-val.	Boots. p
CO2-Invest	Brazil	2.000	0.484	0.785	22.356	0.034	0.370
	Russia	1.000	1.473	0.225			
	India	3.000	0.578	0.901			
	China	1.000	3.356	0.067			
	South Africa,	1.000	0.967	0.326			
	Turkey	3.000	13.301	0.004			
Invest-CO2	Brazil	2.000	7.643	0.022	26.433	0.009	0.702
	Russia	1.000	0.084	0.772			
	India	3.000	7.582	0.055			
	China	1.000	0.352	0.553			
	South Africa,	1.000	0.116	0.733			
	Turkey	3.000	12.931	0.005			
CO2-RD	Brazil	1.000	0.008	0.929	2.184	0.999	0.615
	Russia	1.000	0.000	0.989			
	India	1.000	0.135	0.713			
	China	1.000	0.169	0.681			
	South Africa,	1.000	0.053	0.817			
	Turkey	1.000	0.010	0.921			
RD-CO2	Brazil	1.000	0.046	0.830	1.602	1.000	0.672
	Russia	1.000	0.002	0.963			
	India	1.000	0.001	0.979			
	China	1.000	0.056	0.813			
	South Africa,	1.000	0.065	0.799			
	Turkey	1.000	0.021	0.884			
Invest-RD	Brazil	3.000	5.033	0.169	20.445	0.059	0.820
	Russia	2.000	6.615	0.037			
	India	3.000	6.845	0.077			
	China	3.000	4.857	0.183			
	South Africa,	1.000	0.629	0.428			
	Turkey	2.000	0.051	0.975			
RD-Invest	Brazil	3.000	2.881	0.410	58.974	0.000	0.793
	Russia	2.000	18.668	0.000			
	India	3.000	13.552	0.004			
	China	3.000	12.624	0.006			
	South Africa,	1.000	4.069	0.044			
	Turkey	2.000	10.603	0.005			

Table 5 presents the results of climate change - FDI and FDI - climate change causality tests. According to the results of Emirmahmutoğlu and Köse's panel causality analysis, firstly, panel Fisher statistics reveal that there is a bidirectional causality relationship between climate change and FDI variables. When the causality is analyzed by country and variable, there is unidirectional causality from FDI to climate change for Brazil, from climate change to FDI for China and from FDI to climate change for India. At the same time, a bidirectional causality relationship was found between climate change and FDI variables for Turkey. Looking at the results of the climate change research and development and research and development tests in Table 8, it is seen that there is no causality relationship between the variables according to the results obtained from Emirmahmutoğlu and Köse panel causality analysis. When the results of FDI-R&D and R&D-FDI causality tests are analyzed, panel Fisher statistics reveal that there is a bidirectional causality relationship between R&D and FDI variables. When the causality is analyzed by countries and variables, it is found that there is a bidirectional causality between R&D and FDI variables for Russia and India, and a unidirectional causality from R&D to FDI variables for China, South Africa and Turkey.

6. Analysis Results for OECD Countries

Table 6. Cross-Section Dependency Test

Tests	CO2		Invest		RD	
CD Test	Stat	Prob	Stat	prob	Stat	prob
Cd LM1 (Bresuch, Pagan 1980)	89.378	0.001	76.572	0.001	196.409	0.001
Cd LM2 (Pesaran 2004 CDlm)	8.202	0.001	6.491	0.001	22.505	0.001
cd LM (Pesaran 2004 CD)	2.352	0.001	2.889	0.002	- 1.781	0.037
Bias-adj. CD test	8.003	0.001	0.470	0.681	10.680	0.000

Table 6 shows the results of the horizontal cross-section dependence test for three different variables of OECD countries. According to the analyzed results, it is determined that there is horizontal cross-section dependence in the series. According to the horizontal cross-section dependence result, second-generation unit root tests should be used.

Table 7. CADF/CIPS Unit Root Test

CO2				Invest				RD			
Level		Difference		Level		Difference		Level		Difference	
Lags	CADF-stat	Lags	CADF-stat	Lags	CADF-stat	Lags	CADF-stat	Lags	CADF-stat	Lags	CADF-stat
4.000	- 2.671	4.000	- 6.236	2.000	0.140	2.000	- 1.255	2.000	- 1.255	2.000	- 8.385
4.000	- 1.896	3.000	- 7.642	2.000	- 1.613	2.000	- 1.511	2.000	- 1.511	2.000	- 7.342
2.000	- 2.670	3.000	- 7.748	2.000	-1.354	2.000	- 1.874	2.000	-1.874	2.000	- 6.224
2.000	- 2.137	3.000	- 7.487	2.000	- 1.151	5.000	- 2.250	2.000	- 2.250	2.000	- 6.412
2.000	- 1.573	2.000	- 5.784	2.000	- 1.918	2.000	- 1.671	2.000	- 1.671	2.000	- 9.778
2.000	- 2.236	2.000	- 5.138	3.000	- 1.423	2.000	- 1.286	2.000	- 1.286	2.000	- 6.811
CIPS-stat=- 2.042		CIPS-stat=- 9.836		CIPS-stat=- 2.171		CIPS--stat=- 2.301		CIPS-stat=-2.301		CIPS-stat= 9.223	

Table 7 analyses the stationarity of the three variables for the OECD countries separately with the CADF test and tests the stationarity of the panel data with the CIPS test. Evaluating the CADF results obtained by application, all the countries examined are stationary at first differences at various levels of significance. When analyzing the CIPS test results obtained by averaging the CADF test statistics, the variables are stationary at first difference. After determining that the series has a unit root process, the Gengenbach, Urbain and Westerlund (GUW) (2016) panel cointegration test, which is one of the panel cointegration tests, is used to analyze whether they have a long-run relationship.

Table 8. Panel Cointegration Analysis Results

	d.y	Coef	T Bar	P-val*
CO_2-Invest	y(t-1)	-0.618	-2.524	>0.1
CO_2-RD	y(t-1)	-0.783	-2.732	<=0.01
Invest-RD	y(t-1)	-0.976	-4.835	<=0.01

The > expression obtained because of GUW co-integration analysis indicates that there is no co-integration relationship between the variables under consideration. Accordingly, it is seen that there is no long-run relationship between climate change and foreign direct investment variables. When the other variables are analyzed, it is seen that there is no long-run relationship between climate change research and development variables. According to the results of the analysis of the remaining variables, there is a long-run relationship between FDI - research and development variables.

Table 9. Emir Mahmutoğlu Causality Test

		Lag	Wald St..	p-val.	Panel Fisher St.	p-val.	Boots. p
CO2-Invest	America	1.000	0.177	0.674	11.905	0.751	0.961
	Italy	1.000	0.036	0.849			
	Canada	1.000	0.141	0.707			
	Spain	1.000	0.003	0.958			
	Portugal	1.000	1.588	0.208			
	Denmark	1.000	0.768	0.381			
	Norway	1.000	1.449	0.229			
	Austria	1.000	0.800	0.371			
Invest-CO2	America	1.000	0.083	0.773	8.388	0.936	0.050
	Italy	1.000	0.459	0.498			
	Canada	1.000	0.360	0.549			
	Spain	1.000	0.287	0.592			
	Portugal	1.000	0.040	0.842			
	Denmark	1.000	0.044	0.833			
	Norway	1.000	0.025	0.874			
	Austria	1.000	1.668	0.197			
CO2-RD	America	1.000	0.185	0.667	5.867	0.989	0.755
	Italy	1.000	1.000	0.407			
	Canada	1.000	0.046	0.830			
	Spain	1.000	0.008	0.927			
	Portugal	1.000	0.035	0.852			
	Denmark	1.000	0.334	0.563			
	Norway	1.000	0.131	0.718			
	Austria	2.000	0.604	0.740			
RD-CO2	America	1.000	0.003	0.958	5.029	0.996	0.776
	Italy	1.000	0.080	0.777			
	Canada	1.000	0.002	0.968			
	Spain	1.000	0.020	0.887			
	Portugal	1.000	0.049	0.825			
	Denmark	1.000	0.006	0.940			
	Norway	1.000	0.010	0.920			
	Austria	2.000	3.460	0.177			
Invest-RD	America	Lag	Wald	p-val	29.831	0.019	0.130
	Italy	1.000	0.057	0.811			
	Canada	1.000	0.020	0.888			
	Spain	1.000	0.194	0.659			
	Portugal	3.000	11.264	0.010			
	Denmark	3.000	5.694	0.128			
	Norway	3.000	11.254	0.010			
	Austria	3.000	5.289	0.152			
RD-Invest	America	1.000	1.999	0.157	21. 972	0.144	0.908
	Italy	1.000	0.267	0.605			
	Canada	1.000	2.849	0.091			
	Spain	3.000	3.600	0.308			
	Portugal	3.000	2.523	0.471			
	Denmark	3.000	7.271	0.064			
	Norway	3.000	2.129	0.546			
	Austria	1.000	0.755	0.385			

Table 9 presents the results of Emirmahmutoğlu and Köse panel causality analysis. First, when the panel Fisher statistics are analyzed, it is found that there is a unidirectional causality relationship from the R&D variable to the FDI variable according to the results of Emirmahmutoğlu and Köse's panel causality study. According to the causality analysis for different variables and countries, there is a unidirectional causality relationship between research and development and foreign direct investment for Canada and a unidirectional causality relationship between foreign direct investment and research and development for Spain. For Denmark, FDI and R&D-related variables are found to have a bidirectional causal relationship.

7. Conclusion

Finally, environmental deterioration, mainly caused by CO2 emissions, has emerged as a serious issue for modern society, with far-reaching implications for global warming. As revealed by this study, CO2 emissions are the largest contributor to greenhouse gas emissions and are directly linked to fast industrialization and foreign direct investment (FDI) flows in many nations. The findings highlight the critical need for global action to combat environmental disasters. International accords, such as the Kyoto Protocol, have played an important role in reducing greenhouse gas emissions, but further commitments are required, especially as industrial activity in developing economies grows.

The report also emphasizes the dual effect of FDI on environmental sustainability. While FDI can boost economic growth and technological innovation, it can also increase environmental deterioration in certain situations, as indicated by the pollution hypothesis. To address this, authorities must take a more nuanced approach to FDI, promoting investments in green technologies and renewable energy industries. Countries can balance economic growth and environmental conservation by encouraging sustainable investments via regulatory incentives and carbon pricing mechanisms. Furthermore, increasing international collaboration between emerging and established countries can help with the transfer of eco-friendly technologies, which benefits both the environment and economic progress.

Finally, the role of R&D spending in combating climate change cannot be emphasized. The findings indicate that R&D efforts, particularly in energy efficiency and renewable technology, are critical to lowering CO2 emissions. Countries must emphasize research into sustainable energy technology and create cooperation between governments, the corporate sector, and academic institutions to improve R&D efficacy in tackling climate change. These measures will not only promote creativity but will also lay the groundwork for long-term development. As a result, a multifaceted policy strategy that includes FDI, R&D, and international cooperation is critical for addressing climate change and guaranteeing long-term economic prosperity.

References

Abdouli, M.; Hammami, S. (2017). Economic Growth, FDI inflows and their impact on the environment: an empirical study for the MENA countries. *Quality & Quantity*, *51*(1), 121-146.

Adebayo, T. S.; Awosusi, A. A.; Rjoub, H., Agyekum, E. B.; Kirikkaleli, D. (2022). The influence of renewable energy usage on consumption-based carbon emissions in MINT economies. *Heliyon*, *8*(2), E08941.

Altun, Y.; İşleyen, Ş.; Görür, Ç. (2018). Türkiye'de eğitim ve sağlık harcamalarının ekonomik büyümeye etkisi: 1999-2017. *Van Yüzüncü Yıl Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *39*, 223–244. Erişim adresi: https://dergipark.org.tr/tr/download/article-file/666931

Banerjee, A.; Dolado, J.; Mestre, R. (1998). Error-correction mechanism tests for cointegration in a single-equation framework. *Journal of time series analysis*, *19*(3), 267-283.

Behdioğlu, S.; Çelik, F. (2016). R&D expenditure and emission: an augmentative neural network-based approach. *Dumlupinar University Journal of Social Science*, 136-150.

Churchill, S. A.; Inekwe, J.; Smyth, R.; Zhang, X. (2019). R&D Intensity and carbon emissions in the G7: 1870–2014. *Energy Economics*, 80, 30-37.

Demir, Y. (2021). Eğitim, sağlık ve ar-ge harcamaları ile ekonomik büyüme arasındaki ilişkinin ARDL sınır testi ile belirlenmesi. *Manas Sosyal Araştırmalar Dergisi*, *10*(3), 1758-1770.

Demir, Y.; Görür, Ç. (2020). Examining the relationship between various energy consumption and economic growth of OECD countries with panel cointegration analysis. *EKOIST Journal of Econometrics and Statistics.*, (32), 15-33. https://doi.org/10.26650/ekoist.2020.32.0005

Dritsaki, M.; Dritsaki, C. (2023). R&D expenditures on innovation: a panel cointegration study of the EU countries. *Sustainability*, *15*(8), 6637.

Gengenbach, C.; Urbain, J.; Westerlund, J. (2016), Error correction testing in panels with common stochastic trends, *Journal of Applied Econometrics*, *31*(6), 982-1004. https://doi.org/10.1002/jae.2475

Haseeb, M.; Kot, S.; Hussain, H. I.; Jermsittiparsert, K. (2019). Impact of economic growth, environmental pollution, and energy consumption on health expenditure and R&D expenditure of ASEAN countries. *Energies, 12*(19), 3598.

Huang, Y.; Chen, F.; Wei, H.; Xiang, J.; Xu, Z.; Akram, R. (2022). The impacts of FDI inflows on carbon emissions: economic development and regulatory quality as moderators. *Frontiers in Energy Research*, *9*, 820596.

IMF (1993), Balance of Payments Manual, http://www.imf.org/external/np/sta/bop/BOPman.pdf.

Işık, N.; Kılınç, E. C. (2014). The relationship between CO2 emissions and energy R&D expenditures in the transportation sector. *Socioeconomics*, (2), 321.

Khan, M.A.; Öztürk, I. (2020). Examining the link between foreign direct investment and environmental pollution in Asia. *Environmental Science and Pollution Research*, *27*(7), 7244-7255.

Lei, R.; Zhang, Y.; Wei, S. (2012). International technology spillover, energy consumption and CO 2 emissions in China. *Low Carbon Economy*, *3*(3), 49-53. doi: 10.4236/Lce.2012.33007 .

Marques, A. C.; Caetano, R. (2020). The impact of foreign direct investment on emission reduction targets: evidence from high-and middle-income countries. *Structural Change and Economic Dynamics*, *55*, 107-118.

Menyah, K.; Nazlıoğlu, Ş.; Wolde-Rufael, Y. (2014). Financial development, trade openness and economic growth in African countries: new insights from a panel causality approach. *Economic Modelling*, *37*, 386-394.

Mucuk, M.; Demirsel, M. T. (2009). Foreign direct investments and economic performance in Turkey. *Selçuk University Social Sciences Institute Journal*, (21), 365-373.

OECDSTAT (2020). https://dataexplorer.oecd.org/vis?pg=0&snb=13&fs[0]=Topic%2C1%7CFinance%20and%20investment= (INVEST Data, 20.05.2023)

OECDSTAT (2020). https://dataexplorer.oecd.org/vis?pg=0&snb=18&fs[0]=Topic%2C1%7CScience%252C%20technology= (RD Data, 20.05.2023)

Öztürk, S.; Saygın, S. (2020). The relationship between real per capita income, foreign direct investments, trade openness and carbon emissions under the structural break in Turkey in the period 1974-2016. *Socioeconomics, 28(*44), 69-90.

Pedroni, P. (2004). Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econometric Theory*, *20*(3), 597-625

Sarkodie, S. A.; Adams, S.; Leirvik, T. (2020). Foreign direct investment and renewable energy in climate change mitigation: does governance matter? *Journal of Cleaner Production*, *263*, 121262.

Shahbaz, M.; Nasir, M. A.; Hille, E.; Mahalik, M. K. (2020). UK's net-zero carbons emissions target: investigating the potential role of economic growth, financial development, and R&D expenditures based on historical data (1870–2017). *Technological Forecasting and Social Change*, *161*, 120255.

Ssali, M. W.; Du, J.; Mensah, I. A.; Hongo, D. O. (2019). Investigating the nexus among environmental pollution, economic growth, energy use, and foreign direct investment in 6 selected Sub-Saharan African countries. *Environmental Science and Pollution Research, 26*, 11245-11260.

Su, Y.; Jiang, Q.; Khattak, S. I.; Ahmad, M.; Li, H. (2021). Do higher education research and development expenditures affect environmental sustainability? New evidence from Chinese provinces. *Environmental Science and Pollution Research*, *28*, 66656-66676.

Usta, C. (2023). The effect of foreign direct investments on environmental pollution: the example of N-11 countries. *International Journal of Economics*, *Business and Politics, 7*(1), 58-73.

Westerlund, J. (2007). Testing for error correction in panel data. *Oxford Bulletin of Economics and statistics*, *69*(6), 709-748.

WorldBank (2020). https://databank.worldbank.org/reports.aspx?source=2&series=EN.ATM.CO2E.PC&country= (CO2 Emissions Data, 20.05.2023).

Xing, Z.; Wang, Y. (2023). Climate risk, climate risk distance and foreign direct investment. *International Journal of Climate Change Strategies and Management*, *15*(1), 41-57.

Conflict of Interest: None.
Funding: None.
Ethical Approval: None.
Author Contributions: Kerem ÖZEN (25%), Cemalettin LEVENT (25%), Burak DARICI (25%) Meltem İNCE YENİLMEZ (25%)

Çıkar Çatışması: Yoktur.
Finansal Destek: Yoktur.
Etik Onay: Yoktur.
Yazar Katkısı: Kerem ÖZEN (%25), Cemalettin LEVENT (%25), Burak DARICI (%25) Meltem İNCE YENİLMEZ (%25)