RESEARCH ARTICLE/ARAŞTIRMA MAKALESİ

Pollution Haven or Environmental Benefit? An Analysis of the Impact of Foreign Direct Investments on Carbon Dioxide Emissions

Kirlilik Cenneti mi Çevresel Fayda mı? Doğrudan Yabancı Yatırımların Karbondioksit Emisyonları Üzerindeki Etkisi Üzerine Bir Analiz

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ABSTRACT

Climate change and the consequential greenhouse effect caused by CO_2 emissions are significant issues. Before the Industrial Revolution, emissions were minimal. Emissions growth remained relatively slow until the mid-20th century. In 1950, global CO_2 emissions were 6 billion tonnes, nearly quadrupled to over 20 billion by 1990. Since then, emissions have continued to rise rapidly, now exceeding 35 billion tonnes annually. A substantial portion of carbon dioxide (CO_2) emissions stems from economic activity. Direct investments from one nation to another contribute to a rise in carbon dioxide emissions despite several factors. Nevertheless, nations and multinational corporations are implementing legislation and allocating more funds to promote eco-friendly investments in response to growing awareness of environmental deterioration. This study, conducted in 20 developing nations from 2002 to 2020, using the Generalized Method of Moments (GMM) analysis, reveals a negative correlation between CO_2 emissions and foreign direct investments and population. Conversely, there is a positive correlation between CO_2 emissions and economic growth. The study's findings suggest a complex relationship between FDI, population, economic growth, and CO_2 emissions.

Keywords: Foreign direct investment, Carbon dioxide emissions, GMM.

JEL Code: F18, F21, Q56

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ÖZ

Günümüzde iklim değişikliği ve buna bağlı olarak CO2 emisyonlarının neden olduğu sera etkisi önemli bir konudur. Karbondioksit (CO2) emisyonlarının önemli bir kısmı ekonomik faaliyetlerden kaynaklanmaktadır. Bir ülkeden diğerine yapılan doğrudan yatırımlar, çeşitli faktörlerin varlığına rağmen karbondioksit emisyonlarının artmasına katkıda bulunmaktadır. Bununla birlikte, çevresel bozulmaya ilişkin artan farkındalığa yanıt olarak, ülkeler ve çok uluslu şirketler çevre dostu yatırımları teşvik etmek için mevzuat uygulamakta ve daha fazla fon ayırmaktadır. Bu çalışma, doğrudan yabancı yatırımlar ile karbondioksit emisyonları arasındaki ilişkiyi analiz etmeyi amaçlamaktadır. Araştırma, 2002'den 2020'ye kadar gelişmekte olan 20 ülkede gerçekleştirilmiştir. Çalışmada kullanılan temel yaklaşım Genelleştirilmiş Momentler Yöntemi (GMM) analizidir. Çalışma, CO2 emisyonları ile hem doğrudan yabancı yatırımlar hem de nüfus arasında negatif bir korelasyon olduğunu ortaya koymaktadır. Buna karşılık, CO2 emisyonları ile ekonomik büyüme arasında pozitif bir korelasyon vardır.

Anahtar Kelimeler: Doğrudan yabancı yatırım, Karbondioksit emisyonu, GMM

JEL Kodu: F18, F21, Q56

Introduction

In a globalization era, foreign direct investment (FDI) plays a pivotal role in economic growth, especially for developing countries (Cai et al. 2022). FDI is described as an investment by an enterprise resident in one economy (the FDI investor or parent enterprise) in an enterprise resident in an economy other than that of the FDI investor (the FDI enterprise or subsidiary or foreign affiliate), which involves a long-term relationship and reflects a lasting interest and control. (UNCTAD, 2007) After nosediving in 2020 because of COVİD-19, global foreign direct investment (FDI) rebounded in 2021. By the time we reach 2022, FDI will have fallen 12% compared to the previous year (UNCTAD,2023).

FDI inflows increase urbanization in host countries, leading to industrialization and growth. On the other hand, FDI inflows, along with increased urbanization and industrialization, may be positively associated with environmental degradation, undermining economic growth. (Abdouli& Hammami, 2018).

Although there is a consensus on the benefits of FDI for host countries, the intricate interplay between economic development and environmental sustainability has become a focal point of academic inquiry. The burgeoning economies of developing countries, driven by an influx of FDI, have witnessed unprecedented growth, raising questions about the environmental repercussions of such economic transformations. especially in economic development, the effects of environmental pollution in these countries have been an important research subject. Two hypotheses stand out in this respect: the Pollution Haven Hypothesis and the Environmental Benefit Hypothesis.

The Pollution Haven Hypothesis is a theory in environmental economics that posits a relationship between environmental regulations, international trade, and pollution. (Eskeland & Harrison, 1997). According to this hypothesis, as countries implement stricter environmental regulations, industries facing higher compliance costs may relocate their production to countries with laxer regulations, often called "pollution havens." The primary

motivation behind this relocation is to minimize the economic burden associated with adhering to stringent environmental standards. The Pollution Haven Hypothesis suggests that industries might seek regions with lower regulatory standards to maintain or improve their global competitiveness. This phenomenon is particularly relevant in the context of globalization and the interconnectedness of economies through international trade. The hypothesis implies that stringent environmental regulations in one country could lead to the relocation of environmentally intensive industries to countries with weaker regulations, potentially resulting in a global redistribution of pollution.

Conversely, the Environmental Benefit Hypothesis is a counterpoint to the Pollution Haven Hypothesis. While the Pollution Haven Hypothesis suggests that industries may relocate to countries with lax environmental regulations to minimize compliance costs, the Environmental Benefit Hypothesis proposes that stringent environmental regulations can lead to positive environmental outcomes. According to this hypothesis, as countries implement and enforce strict environmental regulations, industries must adopt cleaner technologies and practices to comply with these standards. This, in turn, can reduce pollution and environmental degradation domestically. Instead of relocating to jurisdictions with weaker regulations, industries may invest in cleaner and more sustainable production methods, ultimately contributing to environmental benefits (Vogel, 2009). The Environmental Benefit Hypothesis emphasizes the potential for a win-win situation where stringent regulations not only protect the environment locally but also encourage the adoption of environmentally friendly practices globally. It challenges the assumption that environmental regulations necessarily lead to the relocation of polluting industries and argues that strong regulations can stimulate innovation, cleaner production processes, and a more sustainable approach to economic development (Zhu et al. 2022).

With increasing globalisation, international organisations have considered the importance of foreign direct investment in the green economy. The Kyoto Protocol, signed within the United Nations Framework Convention on Climate Change, is the only international framework for combating global warming and climate change. Countries that have signed this protocol have promised to reduce their emissions of carbon dioxide and five gases that cause the greenhouse effect or, if they cannot do so, to increase their rights through carbon trading. The Clean Development Mechanism (CDM) is a carbon offset programme run by the United Nations that allows countries to finance projects that reduce greenhouse gas emissions in other countries and claim the saved emissions as part of efforts to meet international emissions targets.

Since FDI and the incentives to be provided under the Clean Development Mechanism (CDM) included in the Kyoto Protocol can have a significant potential to mitigate the effects of climate change, the greening of FDI should be essential (Zhang & Maruyama, 2001). Foreign Direct Investment (FDI) incentives under the Clean Development Mechanism (CDM) are designed to attract capital from developed countries to finance environmentally sustainable projects in developing countries. By channelling FDI into clean energy projects, waste management systems and other environmentally friendly initiatives, developing countries can accelerate their transition to low-carbon economies and, at the same time, benefit from technology transfer and expertise provided by international partners. CDM projects also generate certified emission reductions (CERs) that investors can use to meet emission reduction targets under international agreements, creating a win-win scenario that encourages global cooperation in the fight against climate change. These incentives not

only stimulate economic growth in developing countries but also contribute significantly to global efforts to reduce environmental degradation.

This study examines the impact of FDI on CO_2 emissions in developing countries using panel data from 20 developing countries. FDI in developing countries either increases or decreases carbon dioxide emissions. There are many studies on this subject, but this study investigates whether the situation is consistent with the pollution haven hypothesis or the environmental benefit hypothesis due to the years considered in this study. To this end, the first section provides an explanation and a comprehensive examination of existing literature. Subsequently, the methodology and dataset section presents the introduction of all variables included in the analysis, the methodology of the study, and the econometric foundations underlying the empirical part. In the results section, the results of the GMM analysis are presented, together with the validity tests, and the study is concluded with the conclusion and evaluation section within the findings.

Literature Review

Many studies are showing the relationship between FDI and CO_2. While some of these studies have been conducted on a single country, others have been conducted on groups of countries. Greening FDI has become important for international organizations (OECD, 2011). A noteworthy finding in the literature is that FDI-financed capital formation reduces carbon intensity. (IMF, 2023). A brief literature review is given below:

Table 1. Literature Review

Author	Years	Countries	Methodologies	Results/ Conclusions
Hoffmann et al. (2005)	1971-1999	Low-income, middle-income, high income countries	Panel Granger Causality	In low-income countries, CO_2-level Granger causes inward FDI flows. For middle-income countries, inward FDI causes CO_2 emissions. Finally, there is no Granger causality for high-income countries.
Blanco et al.(2013)	1980-2007	South American countries	Panel Granger Causality	There is the Granger causality between FDI and CO_2 in pollution-intensive sectors. For other sectors, there is no evidence of a relationship between FDI and CO_2.

Abdouli and Hammami (2018)	1990-2012	MENA Region	GMM	There is evidence of a bidirectional causal relationship between economic growth and FDI inflows, between economic growth and CO_2 emissions, and unidirectional causality from FDI inflows to CO_2 emissions.
Kurt, Kiliç, and Özekicioğlu (2019)	1974-2014	Türkiye	ARDL bounds test	GDP per capita decreases CO_2 emissions, and FDI and energy consumption increase CO_2.
Jafri et al. (2022)	1981- 2019	China	NARDL	Both positive and negative changes in FDI have a positive effect on CO2. In the long run, positive change is more effective than negative change.
Ghazouani (2022)	1980-2016	Tunisia	Bootstrap ARDL bounds test	CO_2 emissions, FDI, urbanization, energy consumption, industrialization, technological innovation, and economic growth are cointegrated in a long-run linkage
Khan, Rana, and Ghardallou (2023)	2000-2016	108 developing countries	Panel cointegration- Panel VECM	When schooling levels are low, there is a positive relationship between FDI and CO2 emissions. After a certain level of schooling, the results are the opposite.

Yu et al. (2023)	2000-2017	57 developed and developing countries	Panel regression model and moderating effect	Institutions ' FDI stock quality and financial depth increase CO_2 intensity in developing countries. For developed countries, contrary to developing countries.
Zhang et al. (2023)	1980-2020	China	VECM	There is a need for incentivised FDI inflows focusing on renewable energy and implementing a carbon tax to address emissions.
Kahiloğul ları (2023)	1996-2018	35 OECD countries	Dumitrescu Hurlin Causality Analysis	FDI, economic growth and population do not have any causality with CO_2 emissions.
Nie et al. (2022)	2003-2018	Belt and Road countries	Panel Smooth transition regression (PSTR)	A threshold effect in the relationship between FDI and CO_2 emissions in Belt and Road countries indicates that FDI inflows have a nonlinear impact on environmental degradation.

Data and Methodology

This study empirically analyses the relationship between FDI and CO_2 emissions for 20 developing countries from 2008 to 2020. Countries that used analysis: Argentina, Brazil, Chile, China, Colombia, Egypt, India, Indonesia, Jordan, Malaysia, Mexico, Pakistan, Peru, the Phillippines, Poland, Russia, South Africa, Thailand, Tunisia, Türkiye. Among the variables in the study, the dependent variable CO_2 refers to CO_2 emissions based on metric tonnes per capita. The independent variables of the study are FDI, GDP and POP. FDI represents FDI net inflows in current US\$, GDPpercap represents GDP per capita current US\$, and POP represents countries' total population in the given years. The variables used can lead to biased results if used in their current form. Therefore, the variables are used in a logarithmic form.

A dynamic panel data model can be written as follows:

$$y_{it} = \beta_1 x + \beta_2 y_{i,t-1} + u_{it} \tag{1}$$

In this model, the lagged value of the dependent variable is associated with the error term. This is because each observation's cross-sectional heterogeneity is the same (Baltagi, 2021). In such a model, the GMM estimator is used. The GMM estimator must meet certain conditions: The number of observations should be large, and the period should be small. Current values of the dependent variable should depend on past values. There should be cross-sectional heterogeneity. Independent variables should not be exogenous.

In this model, the lagged value of the dependent variable is associated with the error term because the cross-sectional heterogeneity is the same for each observation (Baltagi, 2021). The cross-sectional heterogeneity term is usually removed by taking the first difference of the model.

$$y_{it} - y_{i,t-1} = \beta_1 (x_{it} - x_{i,t-1}) + \beta_2 (y_{i,t-1} - y_{i,t-2}) + (u_{it} - u_{i,t-1}) \tag{2}$$

In the newly formed model, the relationship between the lagged dependent variable and the error term still persists. GMM estimators are used to eliminate this situation. Since the first difference of the model in equation (2) is taken, cross-sectional effects are eliminated, but the relationship between $y_{it} - y_{i,t-1}$ and $u_{it} - u_{i,t-1}$ persists; that is, they are not orthogonal. This relationship arises from the correlation between $y_{i,t-1}$ and $u_{i,t-1}$. The GMM estimator was introduced by Arellano and Bond in 1991 (Arellano & Bond, 1991). This method is used when there is autocorrelation between error terms.

According to the abovementioned explanations, the model is given below:

$$\ln CO2_{it} = \beta_0 + \beta_1 \ln CO2_{i(t-1)} + \beta_2 \ln fdi_{it} + \beta_3 \ln gdppercap_{it} + \beta_4 \ln pop_{it} + u_{it} \tag{3}$$

The term "i" denotes the country dimension, and "t" denotes the time dimension.

Table 2. Variable Definitions

Variable Name	Signs	Definition	Source
CO$_2$ Emissions	CO$_2$	CO$_2$ emissions metric ton per capita	WDI
GDP per cap	gdppercap	GDP per cap current US dollar	WDI
FDI	fdi	Foreign direct investment net inflow current US dollar	WDI
Population	pop	Total Population	WDI

Empirical Results

Table 3. Decriptive Analysis

Variable	Mean	sd	Min	Max
lnCO$_2$	-0.4085005	1.988832	-1.509716	22.41668
lnfdi	22.82368	2.67547	-0.4596146	26.39634
lnpop	18.00681	2.199272	-0.496984	21.06763
lngdppercap	8.713377	1.449679	-0.4774293	21.00543

The dataset comprises the natural logarithms of CO_2 emissions per capita (lnCO$_2$), FDI (lnfdi), population size (lnpop), and GDP per capita (lngdppercap) for 20 developing nations from 2002 to 2020. The descriptive statistics highlight the primary features of the dataset. Specifically, the distribution of lnCO$_2$ is right-skewed, with a mean of -0.4085 and a high standard deviation, suggesting variability and possible outliers. With a mean of 22.8237, the natural logarithm of FDI (lnfdi) exhibits a right-skewed distribution, suggesting significant variability. The population size measure, lnpop, is right-skewed and has a mean of 18.0068, showing a range of population sizes. At last, the natural logarithm of GDP per capita, or lngdppercap, exhibits a mean of 8.7134 and a right-skewed distribution. These figures serve as important markers of core tendencies.

Table 4. Correlation Matrix

	lnCO	lnfdi	lnpop	lngdppercap
lnCO	1			
lnfdi	-0.1688	1		
lnpop	0.0322	0.8849	1	
lngdppercap	0.6029	0.4663	0.3973	1

The relation between the natural logarithms of GDP per capita (lngdppercap), population size (lnpop), FDI (lnfdi), and CO_2 emissions per capita (lnCO$_2$) for 20 developing nations from 2002 to 2020 is displayed in the correlation matrix. The weak negative correlation between lnCO2 and lnfdi indicates a marginal trend for CO2 emissions per capita to decline as FDI rises. There is almost little association between lnCO$_2$ and lnpop, indicating that the population size has little to no linear impact on CO_2 emissions per person. On the other hand, a high positive correlation between lnCO$_2$ and lngdppercap suggests a positive relationship between economic development and carbon emissions, with CO_2 emissions per capita tending to increase as GDP per capita increases. Furthermore, there is a considerable positive association between FDI and GDP per capita, as indicated by the very high correlation between lnfdi and lnpop and a moderately positive relationship between lnfdi and lngdppercap. These correlations provide a basis for understanding the complex dynamics between economic factors, population size, and environmental outcomes in the developing countries analyzed.

Table 4. GMM Results

l.lnCO$_2$	0.0141** (0.00656)
lnfdi	-0.147*** (0.0208)
lngdppercap	1.624*** (0.0103)
lnpop	-0.422*** (0.0266)

Note: ***p<0.01, **p<0.05, *p<0.10

The GMM analysis of the relationship between CO_2 emissions per capita and important factors such as FDI, GDP per capita, and population in 20 developing countries between 2002 and 2020 reveals noteworthy findings.

The positive coefficient of the previous year's natural logarithm of CO_2 emissions ($lnCO_2$) indicates a significant dynamic, positive relationship with CO_2 emissions per capita. This reflects the tendency for increasing logarithmic CO_2 emissions to correspond to higher emissions per capita.

The negative coefficient for the natural logarithm of FDI (lnfdi) is noteworthy and highly significant. This suggests that as FDI increases, CO_2 emissions per capita decrease significantly. A plausible interpretation is that FDI can help reduce carbon emissions in host developing countries by introducing cleaner and more sustainable technologies. A spatial analysis was made for China; FDI provides CO_2 reduction, especially in the western to eastern region. Technology transfer through FDI can help domestic firms adopt and innovate new technologies, improve energy efficiency, and promote a low-carbon economy (Zhang & Zhou, 2016). Environmental regulations have a crucial role, and FDI has a negative impact on environmental degradation as well. (Akbulut ve Burçin Yereli 2023) studies are investigated, there is a negative relationship between FDI and CO2 emissions after the threshold level of the environmental policy stringency index. The OECD measures the environmental policy stringency index. Stringency is the degree to which environmental policies place an explicit or implicit price on polluting or environmentally harmful behaviour. The index is based on the stringency of 13 environmental policy instruments, primarily related to climate and air pollution (Kruse v. 2022). In our study, the OECD measures ten countries with this index (Chile, Mexico, Poland, Switzerland, Brazil, China, India, Indonesia, Russia, and South Africa). Index values in this country have increased year by year. The increase in this value causes FDI coming to countries to become more environmentally friendly over time.

Furthermore, the positive coefficient on the natural logarithm of GDP per capita (lngdppercap) indicates a positive relationship with CO_2 emissions per capita. This is consistent with the conventional view that economic development is associated with increased energy consumption and carbon emissions.

Additionally, the negative coefficient for the natural logarithm of population (lnpop) shows a significant inverse relationship. Per capita CO2 emissions decrease significantly as the logarithm of population size increases. This suggests that population size has a potential impact on emissions.

In conclusion, the GMM analysis sheds light on the complex interactions between economic development, foreign investment, population size, and environmental outcomes. The observed negative relationship between FDI and per capita CO_2 emissions provides compelling evidence for FDI's role in promoting cleaner technologies and practices in developing countries. Further research through case studies and in-depth analysis is needed to understand better the mechanisms underlying these relationships and to inform sustainable development policies.

Conclusion

In this study, we analyze the relationship between CO_2 emissions -one of the primary drivers of climate change- and foreign direct investments, a key component of international trade, across 20 countries from 2002 to 2020. In this context, while our independent variable was CO_2 emissions per capita, our dependent variable was FDI net inflow. Population and GDP per capita were used as control variables. However, this gives us a narrow point of view. Many factors affect CO_2 emissions. Some of these include industrial activities, energy production, transportation, land use, collective consumer behaviour and choices, and migrations. These factors were out of scope in our study, which is one of the study's limitations. The main goal is to reveal whether the years and countries we discussed in the study acted according to the pollution haven hypothesis or the environmental benefit hypothesis. Different studies in the literature obtain different results. The results supporting both hypotheses mentioned in the study are available in the literature. The findings in this study say that the environmental benefit hypothesis is valid. It is thought that this is due to countries regulating environmental rules and multinational companies investing in environmentally friendly technologies. In previous studies, it was generally observed that foreign direct investments increased carbon dioxide emissions in developing countries; so, it seems that the results of most of the studies in the literature are in line with the pollution haven hypothesis, but it is clear that this situation has begun to reverse with increasing environmental sensitivity and environmentally friendly incentives. This situation can be tested in various ways with different country groups and variables in the future.

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