2ème Conférence Internationale sur l'Economie et la Finance Internationale (EFI-2025)
Proceedings Book Series -PBS- Vol 20, pp.1-17

The Impact of Foreign Direct Investment on Environmental Development: An Empirical Analysis Using the SGMM Model

Hanen ALAYET[1] and Khemais ZAGHDOUDI[2]

hanenalayet96@gmail.com

Faculty of Economics and Management, Sousse University, Tunisia

VPCN, Faculty of Law, Economics, and Management, Jendouba University, Tunisia

k.zaghdoudi@yahoo.fr

VPCN, Faculty of Law, Economics, and Management, Jendouba University, Tunisia

Abstract

The aim of this study is to investigate the effect of foreign direct investment (FDI) on environmental development, also known as environmental quality, for a sample of 97 developing countries observed over the period 1996-2021. The econometric approach applied in this study is based on dynamic panel data, in particular on the two-stage SGMM (System Generalized Method of Moments) estimator. The main results of our study lead us to conclude that FDI has a positive and statistically significant impact on environmental degradation. This can be expressed by the fact that developing countries see FDI as one of the main factors driving economic growth and development, but to the detriment of the host countries' ecological situation. This is true in the first phase of growth, but once a certain threshold of growth has been reached, developing countries turn their attention to improving environmental quality by reducing environmental damage.

Keywords: Foreign Direct Investment (FDI), environmental development (environmental quality), two-step SGMM.

1. Introduction

Environmental quality refers to the overall condition of the environment in which individuals live, work, and interact. It encompasses various aspects, such as air quality, water quality, soil quality, and ecosystems, as well as the management of natural resources and the reduction of environmental harm. A high-quality environment indicates one that promotes biodiversity, ensures renewable resources, and fosters a healthy and sustainable living environment for current and future generations. Environmental quality is now a global concern, particularly in response to issues such as climate change, deforestation, and the decline of biodiversity. To maintain this quality, it is important to implement effective policies for waste management, reduce greenhouse gas emissions, and preserve biodiversity. Social and economic problems are linked to environmental issues, as degraded environments can directly affect public health, economic performance, and social disparities.

Indeed, following globalization and financial liberalization, the increasing inflow of foreign direct investment (FDI) generates economic growth, but at the cost of environmental quality, which continues to deteriorate. Currently, and without interruption, the ecological situation is considered one of the major challenges putting pressure on political authorities and environmentalists.

[1]Faculty of Economic Sciences and Management of Sousse, University of Sousse, Tunisia& VPNC, Faculty of Legal, Economic, and Management Sciences of Jendouba, University of Jendouba, Tunisia.
[2]VPNC, Faculty of Law, Economic, and Management Sciences of Jendouba, University of Jendouba, Tunisia.

ISSN: 2961-6611

In other words, the more prosperous the economy, the more environmental quality suffers. This is the result of several factors, including greenhouse gas emissions, atmospheric pollution, toxic emissions, deforestation, and global warming. Recent studies focus on the role of attracting foreign direct investment (FDI) in environmental degradation, but the findings are mixed. In fact, several studies have demonstrated that foreign direct investment has a positive effect on environmental quality Ahmed and al. (2021), Asghari (2013). However, other research has shown that the attraction of capital flows leads to ecological degradation, as the majority of international investments in host countries are polluting projects Benzerroukand al. (2021),Bokpin (2017) and Baek (2016).

An analysis conducted on 97 developing countries reveals that foreign direct investment initially deteriorates environmental quality, but a threshold is reached where these flows contribute to improvement. Trade openness amplifies pollution, although its effects vary by region, and institutional quality emerges as an important lever to mitigate environmental damage.

This paper aims to analyze the effect of foreign direct investment on environmental quality. The rest of the paper is organized as follows: the first part, presents the review of the empirical literature on this topic. In the second part, we focus on the empirical estimation of the model and its results, both aggregated and disaggregated.

2. Empirical literature review

Although many studies focus on reducing environmental damage in developing countries, the findings are not unanimous. Empirical evidence shows that the impact of FDI on environmental degradation depends on many factors, including institutional quality, the characteristics of host countries, the quality of the labor market, and especially the policies used to attract FDI, among others. The empirical literature has shown that while FDI is an increasingly important "engine" for economic growth and development in many countries, its potential environmental consequences must also be considered when evaluating these impacts.

In this context, the pollution halo hypothesis suggests that industries transfer their clean technologies through FDI flows to host countries. This hypothesis argues that the entry of foreign capital contributes to improving the environmental quality of host countries. Empirical studies that have validated the existence of this hypothesis include: Limazie and Woni (2024), who aimed to analyze the impact of FDI and governance effectiveness on CO_2 emissions. They conducted their study using the Generalized Method of Moments (GMM) on all countries in the Economic Community of West African States (ECOWAS) for the period 2005-2016. The results of the aggregated estimation indicate that FDI flows negatively affect environmental damage. Similarly, the interaction between FDI and governance quality contributes to reducing environmental pollution. According to them, FDI entry and institutional quality generate the degradation of toxic emissions (CO_2). Furthermore, Yuan and al. (2022) studied data from 30 Chinese provinces during the period 2005-2017. They concluded that FDI has a negative and significant impact on pollutant emissions (CO_2). According to them, FDI inflows lead to a reduction in toxic emissions through technological progress. In the same context, they found that green innovation and institutional quality improve environmental quality. Regarding Vitenu-Sackey (2020), who conducted a study aiming to assess the impact of financial development and FDI on environmental quality, measured by carbon emissions (CO_2), he performed a comparative analysis between two regions: one comprising 10 West African countries and the other comprising 7 Southern African countries for the period 1995-2015. Using the two-step Generalized Method of Moments (GMM), the results revealed that although financial development has a positive impact on carbon emissions, FDI has a negative impact on CO_2 emissions in both regions. Moreover, in a study on the relationship between FDI, energy consumption, and environmental pollution in the six member countries of the Gulf Cooperation Council (GCC) from 1990-2014, Rafindadiand al.

ISSN: 2961-6611

(2018) used the Pooled Mean Group (PMG) method. The results of their estimation concluded that the introduction of foreign capital negatively affects environmental degradation. In other words, according to them, FDI improves environmental quality in the aforementioned sample of countries, while energy consumption has a positive effect on CO2 emissions in the region.

However, other research has found that FDI contributes to worsening the ecological degradation problem in developing countries. For these studies, the Pollution Haven Hypothesis (PHH) is validated. They concluded that polluting industries move to regions where environmental regulations are less stringent, and these regions attract such industries in an attempt to foster economic growth without considering environmental damage. Among the works that found that FDI deteriorates environmental quality are Sané (2024), who studied the impact of FDI and institutional quality on environmental quality, measured by CO2 emissions, for the period 1990-2022 in 43 Sub-Saharan African countries. She used dynamic panel data with the two-step System Generalized Method of Moments (SGMM). The study indicates that FDI has a positive and significant impact on environmental degradation. In the same vein, Afo-Loko (2024) aims to study the link between FDI, energy transition, and environmental degradation in Sub-Saharan Africa during the period 1985-2020. The results demonstrate that the Pollution Haven Hypothesis is confirmed, and that renewable energy contributes to improving environmental quality. Furthermore, the combined impact of FDI and energy transition reduces environmental pollution. Additionally, Massaoudi and Baddih (2023) studied the relationship between FDI, carbon emissions, and economic growth in Morocco from 1991 to 2019. Using Ordinary Least Squares (OLS), the regression results revealed that FDI leads to increased pollutant emissions. This proves the validity of the "Pollution Haven" hypothesis.

Furthermore, to analyze the impact of trade liberalization on environmental quality, including the role of institutions, Hakimi and Hamdi (2019) based their study on dynamic panel data from a sample of 143 countries, including 100 developed countries and 43 developing countries, over the period 2006-2015. According to them, the aggregated estimation results indicate that FDI generates environmental degradation by increasing toxic emissions, as foreign investors have invested in polluting projects.

3. Foreign direct investment and environmental development: Empirical validation

3.1 Data, model, and variables

For this research project, we collected data from 97 developing countries over the period 1996-2021. The sample is divided into three sub-sample groups comprising 17 Latin America and the Caribbean countries, 30Asian countries, and 50 Africancountries. We used World Bank Indicators (WDI) and World Governance Indicators (WGI). To study the impact of FDI on environmental quality, we have chosen the following model inspired by the literature we consulted from Dhrifiand al. (2020), Hakimi and Hamdi (2019).

The model presented below analyzes the effect of foreign direct investment on environmental quality using an appropriate econometric method. It aims to explain the key relationships and dynamics between these variables.

$$\mathbf{QE_{it} = \beta_{it} + \beta_1\, QE_{it-1} + \beta_2\, FDI_{it} + \beta_3\, FDI^2_{it} + \beta_4\, DE_{it} + \beta_5\, DE^2_{it} + \beta_6\, OPEN_{it} + \beta_7\, GP_{it} + \beta_8\, RQ_{it} + \varepsilon_{it}}$$

With:

ISSN: 2961-6611

QEis environmental development (or environmental quality) is measured by the growth rate of CO2 emissions (metric tons per capita). **FDI** represents net inflows of foreign direct investment in (% of GDP). **FDI²**is net FDI inflows squared (as% of GDP). **DE** represents economic growth and is measured by the growth rate of gross net income per capita. **DE²** is the growth rate of gross net income per capitasquared. **OPEN** trade openness and is measured by the sum of exports and imports in (% of GDP). **GP** reflects population growth (% annual). Finally, **RQ**stands for regulatory quality. This indicator represents the quality of institutions. It reflects the government's ability to formulate and implement sound policies and regulations that enable and promote private sector development.

3.2 Characteristics of variables

3.2.1 Descriptive analysis

Table 1 below discloses the descriptive statistics of all the variables used in our study. It presents environmental development, also referred to as environmental quality (**QE**), measured by the average annual growth rate of CO2 emissions for the entire sample, which is 2.590%, with a minimum of -66.759% and a maximum of 177.409%. Net inflows of foreign direct investment (**FDI**) represent, on average, 4.071% of GDP of the economies we have selected, with a minimum of -37.173% and a maximum of 103.337%. Foreign direct investment squared (**FDI²**) represents, on average, 56.547% of the GDP for the 97 developing countries we have selected, with a minimum of 0% and a maximum of 10678.62%.

Economic growth (**DE**), measured by the growth rate of gross national income per capita, averages 2.179% during the study period of 1996-2021 study period, with a minimum of -25.167% and a maximum of 46.250%. For economic growth squared (**DE²**), it averages 28.852% over the 1996-2021period, with a minimum of 0.00005% and a maximum of 2139.097%.

The majority of developing countries are very open to the outside world, since their trade openness (**OPEN**), measured as a percentage of their GDP, averages 72.750%. The lowest rate trade openness is 0.027%, while the highest is 347.997%. For demographic growth (**GP**), measured by the annual populationgrowth rate,averages 1.711%, with a minimum of -10.955% and a maximum of 16.625%.

Table 1 above also shows that regulatory quality indicator (**RQ**), which measures institutional quality, is negativeon average, at around -0.5. Developing countries that we have selected suffer from low institutional quality, which can hinder the attraction of FDI. We find the minimum is equal to -2.366, and their maximum is equal1.298.

3.2.2 Correlation matrix

Table 2 shows the correlation matrix between the variables we have chosen.The results presented in Table 2 show that all correlation coefficients between the explanatory variables are low. This proves that there is no problem of multicollinearity between the variables.

3.2.3 Stationarity of variables

The main unit root tests applied to identify the stationarity of all the variables we retained in the regression are: Levin, Lin, and Chu (2002) (LLC), Im, Pesaran, and Shin (2003) (IPS), and Phillips-Perron (1988) (PP). The results reveal that all the variables we have chosen are stationary in level. For this reason, we will apply regression using the two-step System Generalized Method of Moments (SGMM).

3.3 Empirical results

ISSN: 2961-6611

3.3.1 Aggregate estimation results

Based on dynamic panel data, we will use the two-step Generalized System Method Moments (SGMM) approach. Table 3 below discloses the aggregate results.

The results reveal that environmental quality is negatively affected by the average annual growth rate of carbon emissions from the previous year. Specifically, a 1% increase in lagged CO_2 emissions leads to a 0.028% reduction in pollution.

Regarding net foreign direct investment (FDI) inflows, their coefficient is positively linked to environmental degradation and statistically significant at the 5% level. This implies that an increase in FDI contributes to environmental pollution, with an increase of 0.190%. On the other hand, squared FDI is negatively related to CO_2 emissions and statistically significant at the 5% level. A 1% increase in squared FDI would reduce carbon emissions by 0.003%. These findings support the hypothesis of a "pollution haven" and the existence of the Environmental Kuznets Curve (EKC) across the countries in the sample. The EKC describes a nonlinear relationship between FDI and environmental degradation. According to the EKC, at the beginning of economic growth, FDI worsens the environment, but at a certain level of maturity, countries focus more on improving environmental quality. These results are consistent with Afo-loko (2024), Sané (2024), Dhrifiand al. (2020), Hakimi and Hamdi (2019), Shahbaz and al. (2015), Omri and al. (2014), Kivyiro and Arminen (2014), and Baek and Koo (2009).

To determine at what threshold environmental quality will improve, we compare the average net FDI inflows (as a percentage of GDP) to the turning point of the variable. On average, FDI inflows represent 4.071% of GDP, while the turning point for FDI is 31,67%. Since the average FDI is lower than the turning point, it indicates that developing countries are still in the growth phase.

As for economic growth, it has a positive impact on CO_2 emissions and is statistically significant at the 1% level. This is because the level of economic growth achieved through pollutive foreign investments generates environmental degradation. In fact, the more prosperous the economy, the worse the ecological situation becomes. The estimation results show that a 1% increase in economic growth will increase CO_2 emissions by 0.427%. However, the square of the gross national income per capita has a negative and significant impact on CO_2 emissions. This confirms the negative relationship of the quadratic term. A 1% increase in the square of economic growth reduces CO_2 emissions by 0.010%. Thus, beyond a certain income level per capita, toxic emissions decrease gradually. These results align with those ofDhrifiand al. (2020), Hakimi and Hamdi (2019), Hakimi and Hamdi (2016), Kivyiro and Arminen (2014), and Pao and Tsai (2011).

Returning to the inflection point, which reflects the level of maturity beyond which the reduction of environmental damage becomes a priority, we find that the average economic growth is 2.179%, while its turning point is 21.35%. Our situation is similar to that of FDI inflows. Thus, both turning points exceed the average of the variable, reflecting that developing countries are still in the early stages of the growth process and have not yet reached the maturity threshold.

Trade openness also harms environmental quality, with a coefficient of 0.198% for a 1% increase. Openness to trade attracts polluting industries and energy-intensive investments in developing countries with lax environmental policies. This is consistent with the conclusions of Afo-loko (2024), Ha and Nguyen (2021), Huynh and Hoang (2019), and Eastin and Zeng (2007).

Moreover, the model estimation reveals that population growth, measured by the population density growth rate, is positively related to CO_2 emissions, but statistically insignificant. It seems that, in the countries selected for this study, population density does not directly affect ecological deterioration.

ISSN: 2961-6611

Referring to institutional quality, the indicator measuring regulatory quality is negatively related to environmental pollution and statistically significant at the 5% level. This means that a 1% increase in regulatory quality would reduce toxic emissions by 4.937% across the sample. This can be explained by the fact that developing countries with better institutional quality contribute to reducing environmental damage. These results are consistent with Ha and Nguyen (2021), Huynh and Hoang (2019), and Ibrahim and Law (2016).

The rest of this section will focus on interpreting the results from disaggregated estimations across three subregions: Latin America and the Caribbean, Asia, and Africa. Table 7 below presents the disaggregated estimation results for each sub-group of economies.

3.3.2 Disaggregated estimation results

According to Table 7 below, the results from the disaggregated estimation show that only in Asia, the variable representing the annual growth rate of environmental degradation lagged is negatively dependent on the environmental quality at time t. This can be explained by the fact that Asian countries prioritize environmental improvement and aim to reduce environmental damage. This result is consistent with Zheng and al. (2022).

In contrast, lagged CO2 emissions have a positive and statistically significant impact on current carbon emissions in the Latin American and Caribbean countries, as well as in African countries. Therefore, toxic emissions remain a major issue with harmful effects on ecological sustainability. This finding is supported by previous research from Sané (2024), Ha and Nguyen (2021), Hakimi and Hamdi (2019), and Grossman and Krueger (1995).

Regarding the relationship between foreign direct investment (FDI) and environmental quality, it is observed that in all the subregions, the two variables are positively related. This corresponds to the idea that in order to achieve a certain level of economic growth, developing countries attract foreign investors who invest in environmentally harmful activities, which in turn lead to environmental damage. This confirms the validity of the “pollution haven” hypothesis. This result aligns with the works ofEdgard (2022), Dhrifiand al. (2020), Shahbaz and al. (2015), Omri and al. (2014), and Hofmann and al. (2005).

In other words, the literature reveals that FDI leads to environmental degradation in the early stages of economic growth, but it begins to reduce pollution once the country reaches a certain level of economic growth. This is known as the Environmental Kuznets Curve (EKC), which represents the non-linear relationship between FDI flows and ecological degradation. To mitigate environmental pollution, developing countries should establish stringent regulatory standards to promote environmental protection through the dissemination of knowledge, skills, and new technologies.

By introducing the square of the EDI, we can determine the turning point for each sub-group of countries, and understand which phase they are in. For Latin America and the Caribbean, the EDI represents an average of3.996%, and their turning point is 3.79%. This reveals that in Latin America and the Caribbean, average FDI is above its turning point. This indicates that this group of countries is at the beginning of the pollution reduction phase. Reaching this phase may be the result of the adoption of modern, cleaner technologies, the use of renewable energies and the implementation of stricter regulatory policies to reduce environmental degradation. In contrast, the situation of Asian and African countries shows that their average capital flows (4.478% and 3.861% respectively) are below the inflection points (16.6% and 25.1% respectively) of the two country samples. This suggests that these countries are still favorable to attracting international polluting investments, as they have not yet reached their inflection point.

ISSN: 2961-6611

Regarding economic growth, it has a positive and significant effect at the 1% level in all three subregions. This indicates that the level of economic growth occurs at the expense of environmental quality in the economies in question. This supports the existence of the pollution haven as a cost of attracting international capital. This is confirmed by the works ofBaglitas (2019), Al-mulali (2012), and Pao and Tsai (2011).

However, the square of economic growth has a negative effect on CO2 emissions, statistically significant at the 1% level for all three economic groups. This confirms the theory suggesting that, in the long term, developing countries stimulate environmental depollution. This result is consistent with those of Jabri et al. (2019), Hakimi and Hamdi (2019), Ibrahim and Law (2015), Kivyiro and Arminen (2014), and Panayotou (1993). Comparing the average of the variable representing economic growth and its inflection point in the three regions, we observe that the average values of this variable are 1.374%, 4.034% and 1.550% in Latin America and the Caribbean, Asia and Africa, respectively. On the other hand, their inflection points in the regression are higher than the mean values (11.86%, 16.37% and 20.73% respectively). This is consistent with the idea that these economies are still in the growth phase of ecological degradation. In Latin America and the Caribbean, the situation is the reverse of that for FDI, with a transition from the pollution phase to the de-pollution phase. In the other two regions, on the other hand, the situation remains similar to that of FDI.

Regarding trade liberalization, measured by the ratio of exports and imports as a percentage of GDP, it is concluded that in Latin American and Caribbean countries and Asia, FDI flows have a negative but non-significant impact on carbon emissions. In contrast, the estimation results suggest that in African countries, trade openness leads to ecological degradation, as it has a positive and significant impact at the 1% level. This means that external openness brings investments to host countries that cause environmental degradation. This result is closely related to the findings of Ha and Nguyen (2021), Vitenu-Sackey (2020), Hakimi and Hamdi (2019), and Abdouli and Hammami (2017).

Population growth affects CO2 emissions positively and significantly at the 1% level only in Latin American and Caribbean countries. A 1% increase in population growth leads to a 35.812% deterioration in environmental quality. The larger the population, the more the environment degrades. This result is induced by the continuous increase in energy consumption. The estimation result is corroborated by studies on African countries by Afo-loko (2024) and NyandaNkwenka (2019). In contrast, the empirical estimation results show that population density has a negative and significant impact on CO2 emissions in African and Asian countries. This suggests that population growth leads to an improvement in ecological quality. This finding is similar to results from Edgard (2022).

Finally, regarding the institutional quality indicator, namely the quality of regulation, although in Latin American and Asian countries, this indicator has no significant impact on toxic emissions, possibly because they do not directly affect environmental quality. However, in African countries, the indicator has a negative and statistically significant impact at the 1% level on carbon emissions. Thislink between the two variables may be induced by strengthening institutional quality and the related reforms, which bring environmental benefits to these countries. In other words, the quality of institutions plays a crucial role in improving environmental quality. These results are supported by Ibrahim and Law (2016) and Culas (2007).

4. Conclusion

In this paper, we aimed to study the impact of foreign direct investment (FDI) on environmental quality for a group of 97 developing countries during the period 1996-2021. We conducted the study

ISSN: 2961-6611

2ème Conférence Internationale sur l'Economie et la Finance Internationale (EFI-2025)
Proceedings Book Series -PBS- Vol 20, pp.1-17

using dynamic panel data, employing generalized method of moments in a two-stage system (SGMM).

The regression results, both aggregated and disaggregated, show that the entry of foreign direct investment is the primary factor driving environmental degradation in host countries. In the countries under study, economic activity is booming, which implies that the ecological situation is deteriorating. This confirms the validity of the "pollution haven" hypothesis, as foreign firms localize their polluting activities in developing countries with weak environmental policies. Moreover, the square of the variable representing net FDI inflows as a percentage of GDP has a significant negative effect for the entire sample and for all three subgroups. This indicates that once foreign capital inflows reach a certain threshold, environmental quality will become a priority and will progressively improve.

The same condition applies to the variable measuring economic growth. Initially, economic growth increases, leading to emissions that harm the environment. Once the gross national income per capita reaches a certain level, environmental quality improves through reduced carbon emissions.

In the same context, we conclude that trade openness is a key factor contributing to environmental degradation in all the countries we selected. It positively influences CO2 emissions, meaning that the more open an economy is to the outside, the more the country suffers ecologically. However, at the disaggregated level, we found that certain economies suffer from pollution due to trade liberalization, such as African countries that attract companies specializing in polluting activities. In contrast, we observe that in Latin American and Caribbean countries, as well as in Asian countries, trade openness has a negative but statistically insignificant impact on toxic emissions.

We also found that population growth has a positive but statistically insignificant impact at the aggregate level. However, at the disaggregated level, specifically in Latin American and Caribbean countries, it has a significant positive effect on environmental degradation. This can be driven by the continuous consumption of non-renewable natural resources, population urbanization, increased industrial activities, and the intense production of waste that negatively affects the environment of the aforementioned countries. Conversely, population growth has a significant negative effect in African and Asian countries. This can be induced by a population that is more environmentally conscious, favoring the use of renewable energy and encouraging the adoption of clean and efficient technologies.

Finally, regarding the institutional quality indicator, the estimation results show that at the global level, the indicator has a significant negative impact on carbon emissions. This is the result of significant intervention by politicians, environmentalists, and society in pressuring governments to improve their institutional quality in order to address the environmental pollution issue effectively. At the disaggregated level, we find that only in African countries does the quality of regulation have a significant negative effect on environmental damage. In other words, strengthening and developing institutional quality in African countries leads to an improvement in the environmental situation.

In conclusion, the study examines the relationship between foreign direct investment (FDI) and environmental quality. The empirical estimation results reveal that developing countries exploit their lax environmental policies to attract more international investors, who bring projects that are generally polluting, with the aim of achieving a certain level of economic growth. Once this goal is achieved, the environmental situation will begin to improve and become a priority.

ISSN: 2961-6611

Appendices

Table 1. Descriptive statistics of variables (Aggregated)

Variables	*Obs*	*Mean*	*Standard deviation*	*Min*	*Max*
QE (%)	2,181	2,590	12,050	-66,759	177,409
FDI (%)	2,446	4,071	6,324	-37,173	103,337
FDI^2 (%)	2,446	56,547	355,176	0	10678,62
DE (%)	1,964	2,179	4,911	-25,167	46,250
DE^2 (%)	1,964	28,852	72,872	0,00005	2139,097
OPEN (%)	2,336	72,750	35,554	0,027	347,997
GP (%)	2,522	1,711	1,427	-10,955	16,625
RQ	2,494	-0,465	0,659	-2,366	1,298

Source: Author's estimates based on Stata 17 software

Variables	*QE*	*FDI*	*FDI^2*	*DE*	*DE^2*	*OPEN*	*GP*	*RQ*
QE	1,000							
FDI	0,065	1,000						
FDI^2	0,055	0,783	1,000					
DE	0,189	0,115	0,036	1,000				
DE^2	0,016	0,080	0,060	0,251	1,000			
OPEN	0,018	0,370	0,238	0,080	0,069	1,000		
GP	0,003	-0,059	0,029	-0,165	-0,038	-0,105	1,000	
RQ	0,028	0,092	-0,034	0,036	-0,059	0,233	-0,274	1,000

Table 2.Correlation matrix

Source: Author's estimates based on Stata 17 software

Table 3. Estimation of the two-step System GMM Model

Variables	*QE*
L.QE	-0,028 (-2,15) **
FDI	0,190 (2,51) **
FDI^2	-0,003 (-1,98) **
DE	0,427 (10,47) ***
DE^2	-0,010 (-6,30) ***
OPEN	0,198 (8,97) ***
GP	0,376 (0,59)
RQ	-4,937 (-2,03) **
C	-14,914 (-6,06) ***
FDI Turning Point	31,67%
DETurning Point	21,35%
AR (1)	-2,77
Pr > Z	0,006
AR (2)	-0,01
Pr > Z	0,991
Sargan test Chi2	42,24
Prob > Chi2	0,374
Obs.	1624

Source: Author's estimates based on Stata 17 software

Note: ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively, and the values in parentheses represent z-statistics.

Table 4. Descriptive statistics of variables (Latin America and the Caribbean)

Variables	*Obs*	*Mean*	*Standard deviation*	*Min*	*Max*
QE (%)	391	2,062	15,676	-66,759	177,409
FDI (%)	435	3,996	3,351	-5,088	20,635

ISSN: 2961-6611

FDI^2 (%)	435	27,170	46,149	0,005	425,806
DE (%)	392	1,374	4,231	-23,997	15,295
DE^2 (%)	392	19,744	42,666	0,0003	575,909
OPEN (%)	409	66,463	29,910	15,636	166,698
GP (%)	442	1,292	0,662	-2,905	2,778
RQ	442	-0,068	0,638	-2,366	1,298

Source: Author's estimates based on Stata 17 software

Table 5. Descriptive statistics of variables (Asia)

Variables	*Obs*	*Mean*	*Standard deviation*	*Min*	*Max*
QE (%)	667	3,604	11,547	-35,084	97,143
FDI (%)	737	4,478	5,970	-37,173	55,070
FDI^2 (%)	737	55,646	212,567	0,00002	3032,738
DE (%)	525	4,034	4,579	-20,763	29,773
DE^2 (%)	525	37,207	62,397	0,004	886,413
OPEN (%)	729	81,471	35,972	21,929	220,407
GP (%)	780	0,766	1,285	-10,955	7,541
RQ	752	-0,335	0,566	-2,243	1,060

Source: Author's estimates based on Stata 17 software

Table6. Descriptive statistics of variables (Africa)

Variables	*Obs*	*Mean*	*Standard deviation*	*Min*	*Max*
QE (%)	1,123	2,172	10,801	-45,902	74,673
FDI (%)	1,274	3,861	7,227	-18,918	103,337
FDI^2 (%)	1,274	67,098	463,717	0	10678,62
DE (%)	1,047	1,550	5,069	-25,167	46,250

ISSN: 2961-6611

DE^2 (%)	1,047	28,072	85,253	0,00005	2139,097
OPEN (%)	1,198	69,590	36,113	0,027	347,997
GP (%)	1,300	2,420	1,310	-6,852	16,626
RQ	1,300	- 0,675	0,635	-2,282	0,900

Source: Author's estimates based on Stata 17 software

Table 7. Results of the two-step SGMM model estimation for each subsample

Variables	*Latin America and the Caribbean*	*Asia*	*Africa*
L.QE	0,297 (1,65) *	-0,204 (-4,32) ***	0,043 (6,77) ***
FDI	11,313 (3,24) ***	0,332 (5,67) ***	0,251 (2,58) **
FDI^2	-1,493 (-4,15) ***	-0,010 (-7,01) ***	-0,005 (-2,27) **
DE	7,948 (7,04) ***	1,277 (8,08) ***	0,456 (17,16) ***
DE^2	-0,335 (-4,75) ***	-0,039 (-6,40) ***	-0,011 (-12,08) ***
OPEN	-0,093 (-0,32)	-0,090 (-1,62)	0,183 (20,84) ***
GP	35,812 (6,92) ***	-7,372 (-3,73) ***	-1,813 (-2,83) ***
RQ	-8,248 (-0,83)	4,375 (1,39)	-11,361 (-6,92) ***
C	-61,576 (-2,97) ***	9,368 (1,14)	-12,832 (-9,17) ***
FDI Turning Point	3,79%	16,6%	25,1%
DETurning Point	11,86%	16,37%	20,73%
AR (1)	-2,28	-2,93	-4,20
Pr > Z	0,022	0,003	0,000
AR (2)	-0,75	-0,19	-0,44
Pr > Z	0,451	0,847	0,662
Sargan test Chi2	1,02	50,54	51,78
Prob > Chi2	0,994	0,146	0,259
Obs.	334	429	861

ISSN: 2961-6611

Source: Author's estimates based on Stata 17 software

Note: ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively, and the values in parentheses represent z-statistics.

The turnaround threshold

Calculating the turning (inflection) point= $(-b \div 2 \times a)$

a : FDI^2 / DE^2

b : FDI/ DE

** *Aggregated*

*** FDI: $-0{,}190 \div 2 \times (-0{,}003) = (-0{,}190) \div (-0{,}006) = 31{,}67\%$

*** DE : $-0{,}427 \div 2 \times (-0{,}010) = (-0{,}427) \div (-0{,}02) = 21{,}35\%$

** *Disaggregated*

** *Latin America and the Caribbean*

*** FDI : $-11{,}313 \div 2 \times (-1{,}493) = (-11{,}313) \div (-2{,}986) = 3{,}79\%$

*** DE : $-7{,}948 \div 2 \times (-0{,}335) = (-7{,}948) \div (-0{,}67) = 11{,}86\%$

** *Asia*

*** FDI : $-0{,}332 \div 2 \times (-0{,}010) = (-0{,}332) \div (-0{,}02) = 16{,}6\%$

*** DE : $-1{,}277 \div 2 \times (-0{,}039) = (-1{,}277) \div (-0{,}078) = 16{,}37\%$

** *Africa*

*** FDI : $-0{,}251 \div 2 \times (-0{,}005) = (-0{,}251) \div (-0{,}01) = 25{,}1\%$

*** DE : $-0{,}456 \div 2 \times (-0{,}011) = (-0{,}456) \div (-0{,}022) = 20{,}73\%$

Table 8. Summary of reversal threshold

ISSN: 2961-6611

	Aggregated	*Latin America and the Caribbean*	*Asia*	*Africa*
FDI	31,67%	3,79%	16,6%	25,1%
DE	21,35%	11,86%	16,37%	20,73%

Source : Authors

Bibliographic References

- Abdouli, M., & Hammami, S. (2017). Investigating the causality links between environmental quality, foreign direct investment and economic growth in MENA countries. International Business Review, 26(2), 264-278. https://doi.org/10.1016/j.ibusrev.2016.07.004

- Afo-Loko, O. (2024). Foreign Direct Investment, energy transition and environmental degradation: Evidence from sub-Saharan African countries. La Revue Internationale des Économistes de Langue Française, 9(1), Article 1. https://doi.org/10.18559/rielf.2024.1.1635

- Ahmed M., Jabeen G., Wu Y. (2021) Heterogeneity of pollution haven/halo hypothesis and Environmental Kuznets Curve hypothesis across development levels of Chinese provinces J. Cleaner Prod., 285, Article 124898.

- Al-mulali, U. (2012). Factors affecting CO2 emission in the Middle East: A panel data analysis. Energy, 44(1), 564-569. https://doi.org/10.1016/j.energy.2012.05.045

- Al-mulali, U., C. F. Tang, and I. Ozturk. (2015), “Estimating the Environment Kuznets Curve Hypothesis: Evidence from Latin America and the Caribbean Countries.” Renewable and Sustainable Energy Reviews 50, p. 918–924.

- Asghari (2013), Does FDI promote MENA region’s environment quality? pollution Halo or pollution Haven hypothesis. International Journal of Scientific Research in Environmental Sciences 1(6), p. 92-100. DOI:10.12983/ijsres-2013-p092-100

- Baek, J. (2016), “Short communication A new-look at the FDI– income– energy– environment nexus: dynamic panel data analysis of ASEAN”, Energy Policy, Vol. 91, pp. 22-27.

- Baek, J., & Koo, W. (2009). A Dynamic Approach to the FDI-Environment Nexus: The Case of China and India. Journal of East Asian Economic Integration, 13.

- Baglitas, H. H., & Öztürk Yaprak, Z. (2019). An empirical analysis of fragile five in the context of the pollution haven hypothesis.

- Benzarrouk Z., Abid M. et Sekrafi H. (2021). Pollution haven or halo effect? A comparative analysis of developing and developed countries, Energy Reports, 7, p. 4862-4871.

- Bokpin, G. A. (2017). Foreign direct investment and environmental sustainability in Africa : The role of institutions and governance," Research in International Business and Finance, Elsevier, 39(PA), p. 239-247. https://doi.org/10.1016/j.ribaf.2016.07.038

- Culas, R. J. (2007). Deforestation and the environmental Kuznets curve: An institutional perspective. Ecological Economics, 61(2), 429-437. https://doi.org/10.1016/j.ecolecon.2006.03.014

- Dhrifi et al. (2020). Does foreign direct investment and environmental degradation matter for poverty? Evidence from developing countries. Structural Change and Economic Dynamics, 52(2). DOI:10.1016/j.strueco.2019.09.008

- Eastin, J., & Zeng, K. (2007). Foreign Direct Investment and Labor Rights Protection in China: A Tale of Two Sectors. In S. Hua & S. Guo (Éds.), China in the Twenty-First Century: Challenges and Opportunities (p. 89-111). Palgrave Macmillan US. https://doi.org/10.1057/9780230607378_5

- Edgard. G. R. (2022). Effet des investissements directs étrangers sur les émissions du méthane dans les pays de l'Afrique de l'Ouest. https://doi.org/10.5281/ZENODO.7439273

- Grossman, G. M., & Krueger, A. B. (1995). Economic Growth and the Environment. The Quarterly Journal of Economics, 110(2), 353-377. https://doi.org/10.2307/2118443

- Ha, T. C., & Nguyen, H. N. (2021). The Role of Institution on FDI and Environmental Pollution Nexus: Evidence from Developing Countries. Journal Of Asian Finance Economics And Business, 8(6), 609-620. https://doi.org/10.13106/jafeb.2021.vol8.no6.0609

- Hakimi, A. & Hamdi H. (2016). Trade liberalization, FDI inflows, environmental quality and economic growth: A comparative analysis between Tunisia and Morocco. Renewable And Sustainable Energy Reviews, 58, 1445-1456. https://doi.org/10.1016/j.rser.2015.12.280

- Hakimi, A., & Hamdi, H. (2019). Environmental effects of trade openness: what role do institutions have? Journal Of Environmental Economics and Policy, 9(1), 36-56.

- 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.

- Huynh, C. M., & Hoang, H. H. (2019). Foreign direct investment and air pollution in Asian countries: Does institutional quality matter? Applied Economics Letters, 26(17), 1388-1392.

ISSN: 2961-6611

- Ibrahim, M. H., & Law, S. H. (2016). Institutional Quality and CO Emission–Trade Relations: Evidence from Sub-Saharan Africa. South African Journal of Economics, 84(2), 323-340. https://doi.org/10.1111/saje.12095

- Jabri, A., Jaddar, A., & Miad, A. K. E. (2019). The relationship between energy consumption, foreign direct investment, growth, and co2 emissions: a time series analysis with structural breaks for Morocco. Revue de Gestion et d'Économie, 7(1 & 2), Article 1 & 2. https://doi.org/10.34874/PRSM.jbe-vol7iss1

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

- Limazie, M. S., & Woni, S. (2024). Foreign direct investment and carbon emissions in ECOWAS: Does good governance matter? Journal of Economics and Development, 26(2), 139-153. https://doi.org/10.1108/JED-08-2023-0158

- Massaoudi, E. M. E., &Baddih, H. (2023). L'impact des IDE sur les émissions de CO2 au Maroc : Étude de causalité. Revue Française d'Economie et de Gestion, 4(9), Article 9.

- Nyanda, patrickgeoffroy N. (2019). Investissements Directs Étrangers et environnement en Afrique Subsaharienne : Une vérification empirique de l'hypothèse du havre de pollution. Journal of Academic Finance, 10(2), Article 2. https://doi.org/10.59051/joaf.v10i2.331

- Omri, A., Nguyen, D. K., & Rault, C. (2014). Causal interactions between CO2 emissions, FDI, and economic growth: Evidence from dynamic simultaneous-equation models. Economic Modelling, 42, 382-389. https://doi.org/10.1016/j.econmod.2014.07.026

- Panayotou, T. (1993). Empirical tests and policy analysis of environmental degradation at different stages of economic development.

- 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.

- Rafindadi, A. A., Muye, I. M., & Kaita, R. A. (2018). The effects of FDI and energy consumption on environmental pollution in predominantly resource-based economies of the GCC. Sustainable Energy Technologies and Assessments, 25, 126-137. https://doi.org/10.1016/j.seta.2017.12.008

- Sané, I. (2024). Reduction des émissions de CO2 en Afrique subsaharienne : Rôle des investissements directs étrangers et de la qualité institutionnelle. Revue Economie, Gestion et Société, 1(43), Article 43. https://doi.org/10.48382/IMIST.PRSM/regs-v1i43.50743

ISSN: 2961-6611

- Shahbaz, M., Nasreen, S., Abbas, F., & Anis, O. (2015). Does foreign direct investment impede environmental quality in high-, middle-, and low-income countries? Energy Economics, 51, 275-287. https://doi.org/10.1016/j.eneco.2015.06.014

- Vitenu-Sackey, P. (2020). Financial Development, Foreign Direct Investment and Carbon Emissions: A Comparative Study of West Africa and Southern Africa Regions. International Review, 6, 1550-1569.

- Yuan, B., Li, C., Yin, H., & Zeng, M. (2022). Green innovation and China's CO2 emissions – the moderating effect of institutional quality. Journal of Environmental Planning and Management, 65(5), 877-906.

- Zheng, J., Ullah, A., Kamal, M., & Wang, H. (2022). Foreign direct investment and carbon emissions in China: Pollution Haven" or "Pollution Halo? Evidence from the NARDL model. Journal of Environmental Planning and Management, 67, p. 1-26.

ISSN: 2961-6611