Journal of Ecohumanism
2025
Volume: 4, No: 1, pp. 5420 – 5436
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i1.6482

Foreign Direct Investment, Institutional and Environmental Quality: An Empirical Analysis of the Sub-Saharan African Region

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Abstract

This paper examines the impact of foreign direct investment (FDI), trade openness, institutional quality, and other independent variables on environmental quality in 37 sub-Saharan African countries observed between 2012 and 2021. The results reveal that trade openness relates to a decrease in carbon emissions, while FDI has a negative effect on these emissions. The study highlights the importance of institutions, recommending countries to focus on improving rule of law and political stability to achieve a higher environment quality. Furthermore, promoting renewable energy consumption is recommended. These conclusions suggest that trade-friendly policies, foreign direct investment (FDI), and institutional reforms are prerequisites to guide countries towards sustainable development and an improvement in environment quality.

Keywords: *Foreign Direct Investment, Institutional Quality, International Trade, Environmental Degradation, Panel.*

Introduction

The impact of corruption and foreign direct investment (FDI) on environmental quality has become a major concern in the wake of the current global ecological crisis. While the fight against corruption and the promotion of better environmental quality are two essential objectives to ensure sustainable development, it is important to understand how these two factors interact and influence each other.

Corruption is a complex and insidious phenomenon that hinders economic and social development, while undermining institutions and governance systems. It takes many forms, including fraud, collusion, embezzlement and favoritism. Corruption can weaken the ability of governments to implement effective environmental policies and enforce existing environmental regulations. Indeed, bribes and corrupt practices can enable some companies to circumvent environmental standards, divert natural resources and exploit ecosystems without regard for the adverse environmental consequences.

On the other hand, foreign direct investment is seen as a potentially powerful engine for economic development and technology transfer. FDI can promote economic growth, job creation and infrastructure improvements. However, the impact of FDI on environmental quality is more complex. On the one hand, FDI can contribute to the adoption of cleaner technologies and improved environmental practices in host countries. Multinational companies can bring specialized knowledge, sustainable practices and higher environmental standards, thereby helping to reduce CO2 emissions and preserve ecosystems. On the other hand, FDI can also increase pressure on natural resources, leading to unsustainable exploitation of ecosystems and higher greenhouse gas emissions, thus contributing to climate change.

Against this backdrop, this study aims to provide an in-depth analysis of the impact of corruption and FDI on environmental quality, focusing specifically on carbon dioxide (CO2) emissions. CO2 emissions are widely recognized as one of the main causes of climate change, which poses a serious threat to the planet and its inhabitants. Understanding how corruption and FDI influence CO2 emissions can provide valuable information for effective environmental policy formulation and informed decision-making.

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The main objective of this study is therefore to determine the extent to which corruption affects CO2 emissions, and how FDI can mitigate or worsen this impact. To this end, we will adopt an empirical approach involving the analysis of economic and environmental data for a sample of selected countries. We will also examine the mechanisms by which corruption and FDI affect environmental quality, focusing on economic, institutional and political channels.

This study is crucial in the current context of climate urgency and the need to strengthen environmental governance. The results of this study could inform policy-makers, regulators and civil society actors on measures to combat corruption, promote sustainable FDI and improve environmental quality. Ultimately, our aim is to contribute to a better understanding of the complex links between corruption, FDI and environmental quality, in order to foster sustainable and fair development for present and future generations.

Through this study, we hope to shed light on the interactions between corruption, FDI and CO2 emissions, as well as on the policies and actions that could foster environment-friendly economic growth. By identifying the underlying mechanisms and providing empirical evidence, we will be able to formulate specific recommendations for policy-makers and stakeholders to promote anti-corruption practices, encourage sustainable investment and reduce CO2 emissions in Sub-Saharan African countries. Such an approach is essential to meeting today's environmental challenges and ensuring a sustainable future for generations to come. It is within this analytical framework that the present study proposes to examine the asymmetrical impact of corruption and FDI on environmental degradation.

Theoretical Background of The Study

The Pollution Havens Hypothesis

According to Li & Xu (2021), Ouyang & Lin (2020) and Grossman & Krueger (1995), during trade openness, developing countries experience significant environmental degradation due to initial economic growth. This is accounted for by the pollution havens hypothesis, which states that developed economies lose a significant part of their competitiveness to polluting activities due to strict environmental regulations on their territory, while developing countries progressively move to more polluting production, transforming themselves into pollution havens.

Classical international trade theory suggests that trade openness allows economies to specialize in products in which they have a comparative advantage. For developing countries, this means that they have an advantage in engaging in polluting activities. However, Antweiler, Copeland and Taylor (2001) pointed out that the location of polluting activities also depended on cross-country variation, so that these activities were more likely to be located in capital-intensive territories. According to Li et al (2021), being a pollution haven does not necessarily mean that the country is polluted. It is enough for a country to have lax environmental regulations and low environmental costs to be an attractive location for polluting activities, whether owned by local or foreign investors. Mani and Wheeler (1998) argued that such environmental laxity and low environmental costs are strong determinants of a developing country's comparative advantage. The industrial relocation of polluting activities has enabled developed countries to take advantage of the low labor costs in developing countries, offsetting automated production in higher-wage economies. This relocation has also had an impact on the economic growth of these countries and the improvement of their workforce's professional skills. Authors such Agyeman, Amponsah, S. K et al (2020) , Zhang, B & al (2021) confirmed that developed countries tended to move their polluting activities to developing countries because of strict domestic environmental regulations. In addition, the pollution haven hypothesis branches into two important sub-hypotheses that represent dynamic extensions of this hypothesis.

"Racing To the Bottom" Hypothesis

Revesz (1992) proposed the "racing to the bottom" hypothesis, whereby developing countries, in order to promote their market competitiveness and improve economic growth, adopt less stringent environmental

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regulations. At the same time, developed countries, faced with various pressures arising from the loss of competitiveness in certain strategic activities, as well as structural unemployment problems, are being pushed to relax their environmental regulations at home. Thus, Revesz (1992) argues that trade openness leads economies with different environmental regulations to converge towards less stringent environmental standards.

"Stuck in the Mud" Hypothesis

Zarsky (1997) formulated a second-order assumption called "the stuck in the mud" hypothesis, which is less pessimistic. It suggests that, instead of relaxing environmental standards, those in power should stop adopting stricter environmental standards. On the one hand, pressures on competitiveness reduce the willingness of countries to undertake unilateral initiatives to protect the environment, as such initiatives impose additional costs on domestic companies. On the other hand, improving environmental regulations through the convergence of environmental policies between the countries concerned requires the intervention of the main competing producers on the market. Consequently, building on the previous line of reasoning, Zarsky (1997) demonstrated that the market is the main driver behind the implementation of adequate environmental policies, and that environmental stakeholders must maintain the status quo or introduce only incremental environmental changes.

Literature Review

Foreign direct investment (FDI) is seen as a key driver of economic growth and development in developing countries. However, the environmental impact of FDI can also be significant, as multinational companies often have lower environmental standards in host countries than in their home countries. This can lead to environmental degradation, polluting emissions and unsustainable use of natural resources. In what follows, we examine the FDI-environment relationship and the environmental impact of FDI.

FDI can have a significant impact on air quality, particularly through greenhouse gas (ghg) and air pollutant emissions. Industries linked to FDI, such as manufacturing and natural resource extraction, can be particularly polluting in terms of ghg emissions such as carbon dioxide (co2), methane (ch4) and nitrous oxide (n2o). FDI can also result in emissions of air pollutants such as fine particles, carbon monoxide (co), sulfur dioxide (so2) and nitrogen oxides (nox). Emissions of these pollutants can be of particular concern in developing countries, where environmental standards may be less stringent and pollution controls less rigorous. In addition, FDI can lead to increased vehicle, ship and aircraft traffic, which can also contribute to air pollution. Transport associated with FDI can also increase demand for fossil fuels, leading to additional ges emissions. In this regard, Zhang, J. et al. (2021) examined the impact of foreign direct investment (FDI) on air pollution in Chinese cities, using panel data from 273 Chinese cities between 2003 and 2016. The results of the study showed that FDI has a significant positive effect on air pollution in Chinese cities, and this effect is more observed in cities with lower economic development levels, poorer environmental governance and higher industrialization levels. The authors suggested that stricter environmental regulations and greater emphasis on the adoption of green technologies could help mitigate the negative impact of FDI on air pollution in Chinese cities. Similarly, Kucukvar et al..(2019) examined the impact of foreign direct investment on air quality in Turkey using panel data on 26 provinces from 2000 to 2014. The results of the study showed that foreign direct investment had a significant and negative effect on air quality in Turkey, meaning that increasing FDI leads to a decrease in air quality. The authors suggested that environmental policies should be strengthened to minimize the negative effects of FDI on air quality in Turkey.

In summary, FDI can contribute significantly to the degradation of air quality, with potentially serious consequences for human health and the environment. Governments and companies must therefore work together to reduce these impacts, notably by adopting cleaner technologies, improving environmental management practices and promoting more effective environmental policies.

FDI can also have a negative impact on water quality. Indeed, FDI-related industrial activities can lead to water pollution through the discharge of toxic waste, the use of harmful chemicals, deforestation and the

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modification of natural ecosystems. Water pollution can have serious consequences on human and animal health, as well as on biodiversity and ecosystems. Hussain, M. et al.. (2019) examined the impact of foreign direct investment (FDI) on water pollution in Pakistan, using panel data from 23 Pakistani cities for the 2005-2015 period. The results showed that FDI has a significant effect on water pollution, particularly in cities with higher levels of FDI and industrial development. The authors concluded that stricter environmental regulations and better environmental governance are needed to mitigate the negative effects of FDI on water quality in developing countries like Pakistan. Anser, M. K et al.. (2020) conducted a study on the impact of foreign direct investment, trade openness, urbanization, and financial development on water pollution in emerging market economies. The results showed that foreign direct investment and urbanization have a significant impact on water pollution in emerging market economies. The authors concluded that effective environmental policies and stricter water pollution standards are needed to minimize the negative environmental effects of foreign direct investment and urbanization.

The impact of FDI on soil degradation can be significant. Mining and quarrying, for example, can cause significant damage to soil and surrounding flora and fauna, particularly through the use of toxic chemicals. Bakhtyar, B., et al.. (2021) conducted a study on the impact of FDI on soil pollution in emerging countries in Southeast Asia using data on 24 countries from 2000 to 2018. The results of the study showed that FDI has a significant effect on soil pollution in these countries, and that manufacturing industries are the main contributors to this pollution. Similarly , Li et al. (2021) showed, using panel data for 31 provinces in China from 2004 to 2018 that FDI has a significant and positive impact on soil pollution in China, and that this impact is greater in regions with a lower economic development and a higher manufacturing intensity. Similarly, intensive agricultural activities linked to biofuel production can lead to soil degradation, loss of biodiversity and water pollution. Studies have shown that increased pressure on land due to FDI can have negative impacts on soil quality and its ability to support agricultural production. Demuro et al. (2020) carried out a literature review on the impact of foreign direct investment (FDI) on biodiversity conservation. Here are some of their main findings: 1. FDI can have both positive and negative effects on biodiversity, depending on the sector of activity, geographic area and local context. 2. The negative impacts of FDI on biodiversity can include the destruction of natural habitats, landscape fragmentation, soil and water pollution, and the over-consumption of natural resources. 3. The positive impacts of FDI on biodiversity can include the funding of conservation projects, the use of cleaner and more sustainable technologies, and job creation in sectors such as ecotourism.

Methodology

The Model

This study examines the impact of institutional quality and FDI on environmental degradation in 37 SUB-SAHARAN AFRICAN countries observed between 2012 and 2021. Data on FDI, inflation, trade openness, environmental degradation, market size, infrastructure, corruption and credit were extracted from the World Bank and countryeconomy.com. The model is as follows:

$$CO2emiss_{it} = \beta 0 + \beta 1FDI_{it} + \beta 2IQ_{it} + \beta 3X_{it} + \varepsilon$$

Where CO2emiss represents CO2 emissions to account for environmental degradation, FDI represents FDI inflows (% of GDP). IQ represents institutional quality through the institutional variables RQ, RL, PSAVT, GE and VA, X denotes the control variables of our study, the model is written as follows:

$$CO2emiss_{it} = \beta 0 + \beta 1FDI_{it} + \beta 2IQ_{it} + \beta 3TRADE_{it} + \beta 4GDPc_{it} + \beta 5CPI_{it} + \beta 6RE_{it} + \beta 7INFRA_{it} + \varepsilon$$

Where GDP is real gross domestic product (GDP) to represent market size, CPI is the consumer price index to represent inflation, INFRA represents mobile cellular subscriptions (per 100 people) to denote infrastructure, TRADE represents trade (% of GDP) and RE measures renewable energy consumption. This model is inspired by the study of H. Khan et al.(2021).

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Table 1. Variables and Data Source

Variables	**Abréviation**	**Data Source**	**Unit**
Foreign direct investment	FDI	World Bank	% of GDP
Environmental degradation	CO2	countryeconomy.com	Ktons
POLITICAL_STABILITY_AND_ABSENCE_OF_VIOLENCE_TERRORISM	PSAVT	WDI	Estimate of governance (ranges from approximately -2.5 (weak) to 2.5 (strong)
REGULATORY_QUALITY	RQ	WDI	Estimate of governance (ranges from approximately -2.5 (weak) to 2.5 (strong)
RULE_OF_LAW	RL	WDI	Estimate of governance (ranges from approximately -2.5 (weak) to 2.5 (strong)
VOICE___ACCOUNTABILITY	VA	WDI	Estimate of governance (ranges from approximately -2.5 (weak) to 2.5 (strong)
GOVERMENT_EFFECTIVENESS	GE	WDI	Estimate of governance (ranges from approxim

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			ately -2.5 (weak) to 2.5 (strong)
CONSUMPTION OF RENEWABLE ENERGY	RE	WDI	Kilotons
Gross Domestic Product at Constant Price	GDP	World Bank	USD ($)
Consumer price index	CPI	World Bank	Index
Trade	TRADE	World Bank	% of GDP
Infrastructure	INF	World Bank	Per 100 people

In the table 2, we present the variables of our study, the unit and the data collection source.

Table 2 lists the countries in our study, i.e. 37 countries in the Sub-Saharan African region:

Table 2. List of Sample Countries

Benin	Congo. Dem. Rep.
Botswana	Congo. Rep.
Burkina faso	Cote d'Ivoire
Burundi	Gabon
Cameroon	Gambie
Cap-Vert	Ghana
Central Africa Rep	Guinée
Guinée équatoriale	Guinée-Bissau
Kenya	Lesotho
Madagascar	Mali
Maurice	Mauritanie
Mozambique	Namibia
Niger	Nigeria
Ouganda	Senegal
Seychelles	Sierra Leone
Soudan	South Africa
Tanzania	Tchad
Togo	Zambia
Zimbabwe	

Descriptive Statistics

This is a fundamental method for the concise synthesis of data. The table below presents descriptive statistics for the main variables in our study over a period from 2012 to 2021, covering 37 Sub-Saharan African countries. These data provide essential insight into the distribution and variability of our variables of interest, contributing to a better understanding of their fundamental characteristics.

The results of the descriptive statistics for a sample of 370 observations reveal significant insights into the main variables studied reported in the table above. Firstly, the annual average volume of CO2 emissions is 1.051468 Ktons with significant dispersion, illustrated by a standard deviation of 1.644271. Foreign direct investment shows substantial variability, with an average of 4.403825 and a wide range from -18.91777 to 57.87725. GDP per capita shows a high average of 2480.617, with values ranging from 261.0194 to

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16992.03, indicating marked differences between countries. Renewable energy (RE) consumption shows an average of 61.14304, suggesting significant variations in the use of renewable energy sources. Finally, the institutional variables show negative means and moderate variability since they are introduced as estimates, highlighting the poor institutional quality in the countries in our sample. These statistical results provide an essential basis for exploring the complex relationships between these variables, offering crucial insights into understanding the impact of FDI and institutional quality on CO2 emissions.

Table 3. Descriptive Statistics

Variable	Obs	Moyenne	Ecart-type	Min	Max
countrycode	370	19	10.69154	1	37
time	370	2016.5	2.876171	2012	2021
CO2	370	1.051468	1.644271	.0251123	8.191153
FDI	370	4.403825	6.79483	-18.91777	57.87725
GPPC	370	2480.617	3244.087	261.0194	16992.03
CPI	370	222.7094	908.8379	103.4109	16245.89
TRADE	370	70.57429	35.26092	.7568755	217.7868
INFRA	370	87.75748	35.74751	22.94044	185.5593
RE	349	61.14304	27.68213	.8	97.03
RL	370	-.6443662	.6230565	-1.841541	1.023956
RQ	370	-.6286977	.5910369	-1.892658	1.196947
GE	370	-.7353507	.6396961	-1.887359	1.16092
PSAVT	370	-.5820873	.8724656	-2.699193	1.111055
VA	370	-.4683385	.7263584	-1.99927	.9741873

Correlation Analysis

This method allows us to examine whether or not there is a multi-collinearity problem between the independent variables. The table below shows the correlation estimates between the variables used in our study. Exploring these correlations is crucial to our understanding of the links between the studied variables.

The results of the correlation analysis show that: Firstly, foreign direct investment shows a moderate positive correlation with carbon dioxide (CO2) emissions as well as with all institutional variables. However, a slight negative correlation is observed between FDI and renewable energy (RE) consumption. As for CO2, a strong positive correlation is noted with GDP, suggesting a possible influence of economic growth on CO2 emissions. These results underline the complexity of interactions between macroeconomic, institutional and environmental variables, providing a solid basis for further analysis of environmental policies and their impact on CO2 emissions on an international scale.

Table 4. Correlation Matrix

Variables	CO2	FDI	TRADE	INFRA	RE	RL	RQ	GE	PSAVT	VA	GDPC	CPI
CO2	1.0000											
FDI	0.0491	1.0000										
TRADE	0.4536	0.3972	1.0000									
INFRA	0.5777	0.0377	0.3630	1.0000								
RE	-0.7327	-0.068	-0.5586	-0.5958	1.0000							

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RL	0.4447	0.0511	0.3700	0.6573	-0.6381	1.0000						
RQ	0.3907	0.0274	0.2766	0.6003	-0.5168	0.9110	1.0000					
GE	0.5681	0.1041	0.4291	0.6933	-0.7012	0.9338	0.9055	1.0000				
PSAVT	0.4720	0.1827	0.5698	0.5277	-0.6388	0.7529	0.6276	0.7317	1.0000			
VA	0.3095	0.0633	0.2945	0.5727	-0.4789	0.8666	0.8479	0.8183	0.6417	1.0000		
GDPC	0.8408	0.1255	0.5901	0.5696	-0.7118	0.4952	0.4068	0.6245	0.5283	0.2683	1.0000	
CPI	-0.0562	-0.049	-0.1867	-0.0210	0.0499	-0.099	-0.171	-0.134	-0.1354	-0.1420	-0.046	1.0000

Econometric Estimates and Main Results

Fixed Effects Model

Firstly, we found that the consumer price index did not show a significant impact on the volume of carbon dioxide emissions, indicating that price increases do not directly influence this process (estimated coefficient of -7.07E-06 , p = 0.8512). Furthermore, an increase in foreign direct investment is associated with a decrease in CO2 emissions, underlining the importance of environmental issues (estimated coefficient 0.003807, p < 0.0199). On the other hand, government effectiveness, political stability, regulatory quality, freedom of expression and state-imposed rights did not show significant effects on the volume of carbon dioxide emissions, implying that corruption in this case is not a major determinant of this phenomenon (respective probabilities: 0.7233; 0.4366; 0.4936; 0.2906; 0.4196). As for GDP per capita and renewable energy consumption, these variables showed significant effects on the volume of carbon dioxide emissions, implying that energy consumption and wealth per capita are in turn determinants of environmental degradation (GDPC: estimated coefficient -0.000308 p =0.0000; RE: estimated coefficient 0.011173, p =0.0002). Paradoxically and unexpectedly, we found that international trade as well as infrastructure have no significant effects on the volume of carbon dioxide emissions (prob 0.3772 and 0.242499) The results are presented in the table below:

In summary, these results are important for understanding the determinants of carbon dioxide emissions in the studied context, highlighting the variables that have a significant impact and those that have a lesser impact on CO2 emissions.

Table 5. Fixed Effects Model Results

Variables	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	1.125446	0.243940	4.6136	0.0000
FDI	-0.003807	0.001627	-2.340359	0.0199
TRADE	-0.000669	0.000757	0.884298	0.3772
GE	0.029680	0.083751	0.354387	0.7233
PSAVT	0.030677	0.039377	0.779065	0.4366
RQ	0.055971	0.081652	0.685483	0.4936

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RL	0.095554	0.090264	1.058601	0.2906
VA	-0.047668	0.058978	-0.808246	0.4196
GDPC	0.000308	1.71E-05	18.05689	0.0000
INFRA	-0.000878	0.000762	-1.152720	0.2499
RE	-0.011173	0.002984	-3.743902	0.0002
CPI	-7.07E-06	3.77E-05	-0.187723	0.8512

Random Effects Model

For the independent variables, we found that renewable energy consumption is negatively associated with the volume of carbon dioxide emissions, with a coefficient of -0.012104. This relationship is highly significant, as the p-value is 0.0000. Foreign direct investment shows a negative relationship with the volume of carbon dioxide emissions, with a coefficient of -0.003770. However, this relationship is statistically significant, with a p-value of 0.0208. GDP per capita has a coefficient indicating its positive effect on the volume of carbon dioxide emissions (0.000311). However, with a p-value of 0.0000, this relationship is statistically significant. Trade and infrastructure do not show statistically significant relationships with the volume of carbon dioxide emissions, with p-values of 0.4410 and 0.2415 respectively. The variables measuring corruption: government effectiveness, political stability, regulatory quality, freedom of expression, and state-imposed rights do not show significant effects on the volume of carbon dioxide emissions, which implies that corruption in this case is not a major determinant of this phenomenon (respective probabilities: 0.7233; 0.4366; 0.4936; 0.2906; 0.4196). In summary, the results of the random effects model suggest that corruption does not have a statistically significant impact on the volume of CO2 emissions in the countries of our sample during the study period. On the other hand, this model shows that some macroeconomic variables such as GDP per capita and foreign direct investments have a statistically significant impact on environmental degradation, particularly CO2 emissions. The details of the estimates are presented in the table below:

Table 6. Random Effects Model Results

Variables	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	1.180104	0.267303	4.414861	0.0000
FDI	-0.003770	0.001624	-2.321762	0.0208
TRADE	-0.000577	0.000749	0.771418	0.4410
GE	-0.028205	0.082775	0.340746	0.7335
PSAVT	0.029677	0.038933	0.762258	0.4464
RQ	-0.058896	0.079771	0.738317	0.4608
RL	0.077694	0.089533	0.867762	0.3861
VA	-0.040585	0.058231	-0.696962	0.4863
CPI	-7.22E-06	3.76E-05	-0.191985	0.8479
GDPC	0.000311	1.64E-05	18.99634	0.0000
INFRA	-0.000882	0.000752	-1.173186	0.2415
RE	-0.012104	0.002699	-4.483727	0.0000

Model Specification: the Hausman Test

The Hausman test is a statistical method used in econometrics to assess the validity of parameter estimates in an econometric model. The table below presents the results of the Hausman test, which allows for the comparison of the performance of the fixed and the random effects models.

The Hausman test revealed a significant difference between the estimates of the fixed effects and random effects models, with a coefficient of (9.876609). However, the associated p-value is high (0.5415), exceeding the threshold of 0.05. This suggests a lack of evidence to reject the null hypothesis of equality of estimates between the models, preventing us to conclude that the independent variables are endogenous. Because of

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the high p-value, the choice between the models remains open, and the random effects model could be retained in the absence of sufficient evidence to prefer the fixed effects model.

Table 7. Hausman Test Results

Statistique	**P-value**
Chi-square = 9.876609	0.5415

Model Correction: Random Effects: Interpretations

Table 9 presents the results of the random effects method corrected for international trade, renewable energy consumption, foreign direct investments, economic growth, and institutional quality. The coefficients of international trade in all models are negative and significant, indicating that trade openness reduces carbon emissions in the panel. The results show that trade is linked to advanced production methods and stimulates the environment. Our results confirm the presence of the Halo pollution effect, in which the transfer of knowledge resulting from contact with some industrialized countries strengthens the host country's green growth by eliminating and reducing carbon emissions.

Our study examined different environment quality factors. We found that foreign direct investments have a positive impact on carbon emissions, while improving environmental quality when it reaches a certain level. FDI is an important factor for environmental quality because it brings new technological innovations and improves energy efficiency, which is beneficial for the improvement of environment quality. Countries should focus on improving innovation and green technologies, given the climate change and environmental issues they are facing. Our results indicate that trade openness is negatively associated with carbon emissions, which proves that trade relates to advanced production methods and stimulates the environment. Countries should further encourage globalization and trade openness, which can transfer green technologies and new knowledge, beneficial for environment quality. Consumption of renewable energy reduces carbon emissions. Our results are consistent with theories that state renewable energy is beneficial for the environment. Therefore, policies on climate change mitigation in most countries should largely focus on converting non-renewable energy into renewable energy, as it is environmentally friendly. Financial development in Sub-Saharan African countries is still poor for funding environment-friendly projects. However, financial development should focus on facilitating green projects in these countries and offering incentives to improve environment quality. Financial institutions and banks should get involved in these activities and projects that recognize the importance of environmental issues. Our results show that economic growth is positively associated with carbon emissions, yet, this growth can play an important role in setting up environment quality policies. The results of the impact of institutional quality on the environment indicate that strong institutions improve environmental performance, while poor institutions damage the environment. Improvement of national laws and regulations is important for enhancing environment quality. Quality institutions can also encourage technology transfer through FDI because quality institutions control other related factors, such as service quality, civil rights, corruption, politics, and accountability, and play an important role in improving environmental governance to maintain resource use. Our conclusions almost support the theoretical assumptions about the role of institutional quality. However, some of the institutional characteristics in our results show that they are still poor in protecting against the harmful effects on the environment. We suggest that countries strengthen their institutions, as this is the most important factor for improving environment quality, since institutional quality is also associated with other factors such as foreign direct investment, energy consumption, and financial development. The results suggest that the panel countries should focus on institutional quality factors, as they are important for safeguarding environment quality and improving economic growth. These results are consistent with the findings of H. Khan et al.(2021).

We include the five indicators used for institutional quality. These variables are voice and accountability, regulatory quality, rule of law, government effectiveness, and political stability. These variables represent both the country's judicial system and the political system. These variables are included in the relationship between the environment and trade to examine more in-depth the role of institutions in trade policies while

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ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i1.6482

monitoring environment quality. The results of the impact of institutional quality on the environment indicate that two variables of the judicial system, namely voice and accountability, and regulatory quality, have a negative impact on carbon emissions. These results indicate that an increase in these two indicators will improve environment quality.

An increase in the rule of law leads to an increase in carbon emissions in the panel, indicating that rule of law is poor and has a negative impact on environment quality. Similarly, only government effectiveness has a negative impact on carbon emissions, while political stability has a positive impact. The results are in line with those of Cansino Muñoz-Repiso et al. (2019), who found that most institutional quality factors reduce pollution. Similarly, the estimated coefficient of GDP per capita in all models is significant and positive. The results show that an increase in economic growth increases carbon emissions, confirming the presence of the Kuznets environmental curve in the panel. More specifically, our findings show that the GDP coefficients are mainly positive in all models and are similar to the conclusions of Hanif et al. (2019) and Muhammad et al. (2020). The coefficient of renewable energy is also significant and negative, indicating that the increased use of renewable energy is beneficial and has no harmful effects on the environment. The current conclusions are consistent with the results of Dogan and Seker (2016) and Liu et al. (2017). Bhattacharya et al. (2017) also confirmed these conclusions.

Table 8. Corrected Model Results

C	1.180104	0.073116	16.14022	0.0000
FDI	-0.003770	0.000422	-8.940596	0.0000***
TRADE	-0.000577	0.000212	2.721607	0.0068***
GE	-0.028205	0.022692	1.242993	0.02147***
PSAVT	0.029677	0.007576	3.917025	0.0001***
RQ	-0.058896	0.019518	3.017474	0.0027***
RL	0.077694	0.024955	3.113332	0.0020***
VA	-0.040585	0.014665	-2.767530	0.0060***
CPI	-7.22E-06	1.21E-05	-0.599182	0.5495
GDPC	0.000311	5.45E-06	57.03026	0.0000***
INFRA	-0.000882	0.000189	-4.671613	0.0000***
RE	-0.012104	0.000613	-19.73990	0.0000***

Analysis of Results & Discussions

Several previous studies have shown that trade openness increases carbon emissions and degrades environment quality, while some researchers argue that trade improves environment quality through composition, trade, and technique effects (M.Z Rafique et al.).(2020).

Our results also indicate that trade openness improves environment quality in the countries in our sample, which shows that there may not be a high volume of trade activities using fossil fuels energy for production and transportation. This finding supports the halo pollution effect hypothesis, which assumes that trade openness improves environment quality through composition, trade, and technique effects. Pollution is increasing due to the growing demand for energy for production, where energy consumption from non-renewable sources destroys environment quality. Our results suggest that use of energy from renewable sources improves environment quality. Our results are consistent with theories that support the idea that renewable energy is beneficial for the environment, leading to lower carbon emissions. The use of renewable energy instead of non-renewable energy presents long-term environmental benefits by replacing energy from dirty sources and fossil fuels with clean energy sources. This also allows for independence of oil-exporting countries from energy imports. This finding is consistent with the results of H. Khan et al..(2021), implying that renewable energy can be produced at the national level, and there will be no need to import energy sources, like oil, from other countries. On the other hand, renewable energy can be linked

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DOI: https://doi.org/10.62754/joe.v4i1.6482

to direct sustainable development because access to these energy sources is easy and it brings economic benefits, mitigates health problems, and reduces social and environmental issues. Our results confirm that the use of renewable energy is beneficial for environment quality and reduces carbon emissions. The results show that countries that use more renewable energy tend more to control environmental degradation and maintain environment quality. The negative impact indicates that there is a greater conversion of non-renewable energy into renewable energy. Renewable energy consumption reduces emissions and plays a very important role in improving environment quality. Therefore, policies on climate change mitigation in most countries should largely focus on converting non-renewable energy into renewable energy, as it is good for the environment. Our results suggest that the proportion of renewable energy in various countries/regions is growing, and it has been converted from non-renewable energy, and people are particularly concerned about this in most countries/regions. The results on economic growth and carbon emissions show that an increase in economic growth will increase carbon emissions. Our results indicate that there is a Kuznets environmental curve, which suggests that economic growth initially increases emissions until a certain level is reached, after which it begins to improve environment quality. In the presence of policies and regulations on environment quality, this method can be implemented, and it is possible to achieve positive outcomes. Over the years, efforts to improve people's well-being through development have led to an increase in production, as well as large quantities of fossil fuels known for their harmful effects on the environment. National development depends on the country's progress and sustainability. The results indicate a non-monotonic inverted U-shaped association between production and the environment. When there is an increase in the square of GDP per capita, carbon emission rate decreases, implying an inverted U-shaped association, in line with the Kuznets environmental curve hypothesis. Our conclusions confirm that per capita income reduces carbon emissions after reaching a certain threshold in the long term. Therefore, the conclusions suggest that policies aimed at increasing income will also be useful for reducing carbon emissions over time in the panel. This indicates that economic growth is driven by energy innovation. Other domestic production resources are also important to promote green growth and protect environment quality. Our results also indicate that a high institutional level enhances environment quality, while low institutional level is associated with lower environment quality. Improving institutions is necessary to enhance environment quality, which includes upgrading national laws and regulations as well as environmental policies. Our results further indicate that government effectiveness is sufficient to protect environment quality in the panel. A better institutional quality reflects human life and rule of law, with this latter supporting economic freedom and market economies, thereby reinforcing environment quality. Strong institutions contribute to the implementation of energy policies and regulations and encourage the use of renewable energy. Strong institutions also control corruption and strengthen the judicial system. All institutions contribute to the implementation of policies on environmental regulations to protect environment quality. It is therefore clear that quality institutions have a significant impact on environmental policies and can help reduce pollution in developing countries and improve incomes. Quality institutions can also encourage technology transfer through FDI inflows, as quality institutions control other related factors, including service quality, civil rights, policy and accountability, and play an important role in strengthening environmental governance to maintain resource use. Our results almost confirm the theoretical assumptions about the role of institutional quality. However, some institutional factors in our study indicate that they are still poor in protecting against their harmful impact on the environment. The results on FDI and carbon emissions indicate that an increase in FDI inflows reduces carbon emissions. These results are consistent with those of M.Z Rafique et al (2020) and B.A Demena et al. (2020). Our results indicate that FDI inflows transfer green technology, which improves environment quality, and the objective of foreign investors is not only to maximize profits but also to protect the environment. This can take place by leveraging several FDI projects in countries using renewable energy instead of fossil fuels energy. The results show that international investors are investing in clean activities, which do not harm environment quality and help reduce carbon emissions. Our results indicate that this degradation can vary from one region to another and from one country to another because of differences in institutional quality. Better governance, strict regulations, and corruption control are likely to have a beneficial effect on environment quality by preventing FDIs geared towards polluting industries and encouraging the development of renewable energy sources as well as the use of green technology. Most of our institutional quality variables are negative and significant with carbon emissions, which is why FDI also reduces carbon emissions, as institutions control FDI policies to avoid investing in polluting industries and

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DOI: https://doi.org/10.62754/joe.v4i1.6482

use green technology. According to our results, financial development increases carbon emissions. Financial development in some countries of the panel has been used for capitalization and considered a factor promoting the growth of small and medium-sized enterprises. These small and medium-sized enterprises offer fewer advantages in terms of economies of scale and emission reductions. Therefore, pollution may increase as a result of financial development. It has been suggested that environment-friendly technologies are not a priority for the financial sector to provide funding. This could be the reason for the increase in pollution. We conclude that financial development does not reduce pollution rate but increases emissions.

Conclusion

This study examines the impact of foreign direct investment, trade openness, institutional quality, as well as other independent variables, on environment quality. The study uses data from 37 Sub-Saharan African countries over the period from 2012 to 2021. Using a random effects estimator, we found that trade openness reduces carbon emissions in the countries in the sample. Our results indicate that trade openness in these countries is associated with advanced production methods, which protect environment quality. Our conclusions confirm the presence of the halo pollution effect, where knowledge transfer resulting from interaction with some industrialized countries strengthens green growth in host economies by eliminating and reducing carbon emissions. We have also found that renewable energy use reduces carbon emissions and is beneficial for environment quality. Pollution in these countries is increasing due to the growing demand for energy for production, where energy comes from non-renewable sources and destroys environment quality. We conclude that these countries are seeking to transition from non-renewable to renewable energy consumption, which can protect environment quality and reduce dependence on the import of non-renewable energy from other countries. The results of GDP per capita show a positive impact on carbon emissions. Our results confirm the Kuznets environmental curve. FDI results show that it negatively affects carbon emissions. Financial development also positively affects carbon emissions, which means that countries need to strengthen environmental financial institutions to provide funding for green technologies and environment-friendly projects. However, our results indicate that the financial institutions of the panel countries are still short-handed in providing such funding for environment-friendly projects, where FDI negatively affects carbon emissions. Most institutional indicators negatively affect carbon emissions, yet, there are still some factors that are positively associated with carbon emissions. Our results recommend that the panel countries focus on improving institutional factors such as rule of law, corruption control, and political instability to achieve a higher environment quality. The study also suggests improving renewable energy consumption to enhance environment quality. Our study is limited to the countries in the sample and the methods used. Future studies can be conducted using different samples and techniques, as well as new factors to more effectively examine this relationship. Our study examined the Kuznets environmental curve and the halo pollution effect hypothesis. Future studies can also focus on testing the role of the Kuznets financial curve in this relationship. We used unique institutional quality indicators as well as an institutional quality index constructed from five indicators, and we determined their role in mitigating carbon emissions. However, there may be an interaction term between institutional quality and other factors such as economic growth and financial development. Future studies may include the moderating role of institutional quality on carbon emissions through these factors. Our sample analyses are conducted for a unique panel; future studies can be carried out on developing and developed countries to differentiate the impact of these factors on carbon emissions, as institutional quality and other factors may not be the same across different country samples.

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ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
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Journal of Ecohumanism
2025
Volume: 4, No: 1, pp. 5420 – 5436
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i1.6482

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