**Assessing the Influence of Foreign Direct Investment on Renewable Energy Adoption in Africa**

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**Abstract**

*This study examines the relationship between foreign direct investment (FDI) and renewable energy consumption (REC) in Sub-Saharan African (SSA) countries, with a focus on the moderating role of environmental policies. Utilizing a dataset spanning 48 SSA countries from 2016 to 2022, the analysis employs the system generalized method of moments (GMM) technique to account for dynamic panel data challenges. The findings reveal that FDI inflows alone do not directly influence REC. However, the interaction between FDI and robust environmental policies significantly enhances REC adoption in the region. Additionally, industrialization and trade openness are identified as critical drivers of increased REC. The study underscores the importance of implementing targeted environmental sustainability policies, including clear regulatory frameworks, incentives such as subsidies, tax breaks, and feed-in tariffs for renewable energy projects, alongside measures to cap or tax carbon emissions. These recommendations aim to foster a conducive environment for integrating renewable energy solutions in SSA economies, promoting sustainable development and reducing dependence on fossil fuels.*

**Keywords:** FDI Inflows, Renewable Energy Consumption, Environmental Sustainability, System-GMM

**JEL:** F21, Q42, Q56, O55.

**1. Introduction**

Following the independence of most African countries in early 1970’s, the development of the countries’ economy has been an important part of their policies. The development of Africa region has necessitated increasing productive activities through intensive investment and industrialization. The Sub-Saharan Africa (SSA) region, comprising of 48 independent nations have been yearning for the development of the individual countries and has experienced increasing Gross Domestic Product (GDP) over the years as depicted in figure 1. The aggregate GDP of SSA was USD 2,011.4 billion in 2022 and estimated to report a yearly growth rate averaging 3.7% (International Monetary Fund [IMF], 2023). The increasing GDP can be attributed to increase in population, urbanization and industrialization.

**Figure 1. Trend of Economic Growth in SSA**

**Source: World Bank (2023)**

It has also been argued that energy is a vital element for production and is subsequently important for economic growth and development (Alaali et al., 2015). Energy consumption is expected to increase with growing population and industrialization especially in certain continents and growing income per capita (economic growth) (Apergis & Payne, 2010a). Moreso, the United Nations (UN) projects that the global population will grow from 7.9billion in 2022 to 10.9 billion by 2100, which is an indication of the potential increase in energy consumption in years to come.

Renewable energy consumption has been found to be an important contributor to economic growth (Apergis & Payne, 2010b) but not as much as conventional energy which generates emission of greenhouse gas when burnt (Adu & Denkyiray, 2019; Radmehr et al., 2021) and increases temperature. The world depends heavily on fossil fuels (oil, gas and coal) as a major energy source because they are energy-rich, that is, they have high energy intensity in size and weight, and relatively cheap to process. Figure 2 shows the relationship between energy consumption and carbon dioxide (CO2) emissions in SSA between 1965 and 2021.

**Figure 2. Relationship between Energy Consumption and Carbon Emissions (CO2) in SSA**

**Source: World Bank (2023)**

From figure 2, CO2 emissions has increased from 399,713.177kt in 1990 to 823786.7kt in 2019. More importantly, CO2 emissions increased by 0.98% from 2016 to 2017, 1.2% from 2017 to 2018, and by 2.75% from 2018 to 2019. The increasing growth rate of CO2 emissions in SSA is alarming, and projected to be 5.8 gigatons per year by 2060 (International Energy Agency [IEA], 2022) which is about the same in USA currently.

Moreover, as Africa countries yearn for economic growth and development, the continent has been seeking intensive investment and been promoting policies aimed at trade integration. One of the attempts is the establishment of regional organizations like the Africa Union (AU) and the Economic Community of West African State (ECOWS). More recently, is the establishment of the African Continental Free Trade Area (AfCFTA) in 2018 to enhance trade openness among African countries. The growth in FDI to the continent could be attributed to the oil and gas sector of the economy, food processing and investment in real estate. Since inception of AfCFTA, the SSA region has experienced increased foreign direct investment (FDI) inflows from $29.08billion in 2018 to $73.89billion in 2021, as depicted in figure 3 below.

**Figure 3. Trend of Foreign Direct Investment inflows in SSA**

**Source: World Bank (2023)**

There is a view that FDI promotes growth not only directly by augmenting capital formation in the recipient economy, but also indirectly by inducing human capital growth, helping technology transfers, and strengthening competition (Kneller & Pisu, 2007). FDI allows businesses cheaper and/or easier access to financial capital, which can be used to expand their existing operations or construct new plants and factories, all of which can impact the production process and the adoption of modern energy sources. Since energy related CO2 emissions is expected to have increased by 40-110% by 2030 (IPCC, 2007), technological transfers through FDI inflows can aid in renewable energy adoption and, in the reduction of CO2 emissions in the region.

Nevertheless, there are concerns that FDI inflows can have significant negative impact on the recipient economy. For example, Zhang (2011) has shown that FDI plays a pivotal role in the increase of CO2 emissions in China. Xing and Kolstad (2002) reported that a positive relationship exists between FDI and pollutant emissions in the host countries. This premise on the notion that, when governments attract FDI to accelerate their economic growth this may instigate foreign investors to relocate their manufacturing plants from home countries with stringent environmental policies on environmental quality, to less developed countries with lax environmental policies. Relocating manufacturing plants that are largely powered by fossil fuels (because they are cheaper) to less developed countries including SSA countries would increase the consumption of fossil fuel in the region and further increase CO2 emissions. Moreover, several studies have shown negative impact of fossil fuels on CO2 emissions (Boontome et al., 2017; Liu et al., 2017; Lotz & Dogan, 2018; Adu & Denkyirah, 2019).

None-the-less, Foreign Direct Investment has emerged as a catalytic force, which could propel the growth of renewable energy infrastructure across the globe. As international investors increasingly recognize the potential returns in the renewable sector, host countries could experience an influx of capital, leading to the development of state-of-the-art wind, solar, and hydroelectric projects. This surge in FDI would not only bolster the financial viability of these initiatives but could accelerate the deployment of cutting-edge technologies, making renewable energy more competitive and accessible. Perhaps, FDI in renewable energy projects could be a potent driver of economic diversification.

Whereas, FDI has become increasingly important, few details have been discussed on its environmental impact to the recipient country, especially in the Sub-Saharan African (SSA) context. Indeed, the rising FDI inflow in developing countries raises an important question regarding whether it has any environmental consequence, on renewable energy consumption, especially as FDI inflows to African countries hit a record of $83 billion in 2021 and $73.89 billion in SSA countries (United Nations Conference on Trade and Development [UNCTAD], 2022).

Despite Sub-Saharan Africa possessing abundant renewable energy sources, the region still faces challenges in providing universal energy access. Renewable energy projects, especially off-grid solutions, can offer opportunities to bridge the gap and reach remote areas. Perhaps, adequate financing and investment could be crucial for scaling up renewable energy projects. Intensive renewable energy use can be a panacea to sustainable development in SSA countries by enhancing economic growth without increasing environmental degradation caused by productive activities in the economy. Moreover, many international environmental and energy organization such as the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA) among many others have claimed that renewable energy resources can offer a significant opportunity for the economic development and environmental quality improvement for many countries around the word (Kahia et al., 2017a). Lee (2019) considered renewable energy development as an effective approach to decrease CO2 emissions and achieve sustainable development goals (SDGs).

Over time, Sub-Saharan African countries have implemented various policies to address carbon emissions, often as part of broader climate change strategies. Under the Paris Agreement, countries in SSA have submitted NDCs, outlining their commitments to reducing emissions and adapting to climate change. However, these commitments vary significantly in ambition and feasibility. For instance, South Africa, the region's largest emitter, pledged to peak its emissions between 2020 and 2025 and to reduce them thereafter. Other countries like Kenya and Nigeria have set more modest targets, often conditional on international support. A key challenge is the implementation of these NDCs, given the region's limited financial and technical resources. Several SSA countries are promoting renewable energy as a way to reduce carbon emissions. South Africa, Kenya, and Ethiopia have made significant investments in solar, wind, and geothermal energy. For example, South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) has added over 6,000 MW of renewable energy capacity since its inception in 2011. However, the region's overall energy mix remains heavily reliant on fossil fuels, particularly coal and oil.

Policies on climate change causes by carbon emissions in Sub-Saharan Africa are evolving, but they face significant challenges. The region's low contribution to global emissions is overshadowed by its high vulnerability to climate impacts. While there are promising initiatives in renewable energy utilization, these are often undermined by limited resources, institutional weaknesses, and competing development priorities. For SSA to effectively address carbon emissions, there needs to be a greater alignment between climate goals and economic development, supported by increased international financial and technical assistance.

Although previous researchers have investigated the linkage between FDI inflows and macroeconomic variables like energy consumption, economic growth and CO2 emissions, they did not include the effect of FDI inflows in the nexus focusing on SSA countries. It therefore becomes imperative to evaluate the impact of FDI inflows on renewable energy consumption in Sub-Saharan Africa, considering the role of environmental policies. This study aims at evaluating the impact of foreign direct investment (FDI) inflow on renewable energy consumption in Sub-Saharan African (SSA) countries.

**2. Literature Review**

The relationship between Foreign Direct Investment (FDI) and renewable energy consumption can be analyzed through various economic theories. The pollution havens and pollution halo hypothesis are considered in this study. The Pollution Halo Hypothesis and the Pollution Haven Hypothesis are two contrasting perspectives on the relationship between environmental regulations, foreign direct investment (FDI), and pollution.

The term "pollution haven hypothesis" was popularized in academic literature, and scholars like J. Peter Neary and Gene Grossman have contributed to discussions on this topic. The Pollution Haven Hypothesis argues that firms will seek to avoid the cost of stringent environmental regulations (and high energy prices) by locating production in countries where environmental norms are flexible. Higher energy prices are indeed associated with higher outward FDI stock at the firm-level. However, the effects are small with respect to other drivers of FDI. The pollution haven hypothesis posits that jurisdiction with weak environmental regulations – ‘pollution havens’ – will attract polluting industries relocating from more stringent locales, thereby increasing nonrenewable energy consumption and increasing CO2 emissions in the recipient countries. In contrast, the Pollution Halo Hypothesis posits that the FDI inflows instigates innovative production process and technological advancement thereby promoting efficiency and improved productivity which can enhance the adoption of energy efficient production process and can lead to decline in CO2 emissions. This hypothesis suggests that FDI can lead to the diffusion of advanced technologies from foreign investors to domestic entities. In the renewable energy sector, this could manifest as the transfer of knowledge, skills, and best practices, enhancing the capabilities of local industries and encouraging wider adoption of renewable technologies. Advocates of the Pollution Halo Hypothesis argue that strong environmental policies can enhance a country's reputation, potentially attracting FDI from industries that prioritize sustainability. This hypothesis aligns with the idea that businesses, in order to maintain a positive public image, may prefer to operate in countries with robust environmental regulations.

Both the Pollution Halo and Pollution Haven hypothesis have been investigated extensively in the existing literature due to global environmental issues such as global warming and climate change (Aliyu, 2005; Ayadi, 2014; Lundh, 2017; Guzel & Okumus, 2020). The establishment of regional and sub-regional economic groups in SSA countries have necessitated intensive FDI inflows accompanied by intensive energy use. The above theories therefore suit the objective to uncover the extent to which FDI inflows impact renewable energy usage in SSA countries either positively (Pollution Halo) or negatively (Pollution Havens).

Another theory worth noting is the Institutional theory, which emphasizes the importance of regulatory frameworks and institutions in shaping economic outcomes. FDI in renewable energy can be influenced by the host country's policies, incentives, and regulatory environment. Countries with clear and supportive regulations may attract more FDI, leading to increased renewable energy consumption.

There have been numerous studies on the relationship between FDI and other economic variables, most especially economic growth, with most witnessing a positive effect of FDI inflow on the economic growth of the host country (Ngonadi et al., 2020; Mujtaba & Jena, 2021; Chen et al., 2023). There have been increasing studies on FDI and renewable energy consumption in both developed and developing countries, due to the increase in carbon emissions from nonrenewable energy usage in most countries arising from rise in FDI. Various research has been conducted on the effects of FDI on carbon emission but not much on the relationship between FDI and renewable energy consumption. Their results still need to be clarified due to contradictions in their findings (Amuakwa-Mensah & Adom, 2017; Hishan et al., 2019; Agyeman et al., 2022; Amoah et al., 2023).

Moreso, a couple of empirical studies have explored the relationship between FDI and renewable energy consumption in Sub-Saharan Africa. This region has attracted FDI as it offers various investment opportunities, including natural resources, infrastructure development, and emerging markets. The relationship between FDI and renewable energy consumption in Sub-Saharan Africa is complex, and findings vary across studies.

Some studies suggest a negative correlation between FDI and renewable energy consumption. This relationship can be attributed to the fact that FDI often leads to increased industrial activity, which, in turn, can result in expatriate and multinational companies relocating their production plants from countries with stringent environmental policies to countries with weak environmental policies, usually underdeveloped countries, leading to higher use on nonrenewable energy sources and increasing CO2 emissions. For example, Omri et al. (2014) investigated the causality between renewable energy consumption, FDI and economic growth using dynamic simultaneous-equation panel data for a global 54 countries over the period 1990-2011. They did analysis for 3 regional sub-panels (Europe and Central Asia, Latin America and the Caribbean, and the Middle East, North Africa, and Sub-Saharan Africa). They discovered bidirectional causality between FDI and economic growth for all panels, and bidirectional causality between FDI and renewable energy consumption for all the panels except Europe and North Asia. Their findings also show bidirectional causality between CO2 emissions and economic growth for the Middle East, North Africa, and Sub-Saharan Africa panel. Whereas, unidirectional causality was found to run from CO2 emissions to economic growth for Europe and Central Asia, and Latin America and the Caribbean panels. In like manner, Chen et al. (2023) argued that FDI inflows had an unfavourable effect on CO2 emissions. This was supported by Nhuong and Quang (2022) who discovered that FDI inflows is positively associated with CO2 emissions in Vietnam.

In another studies, Mahmood et al. (2019a, 2019b), using spatial econometrics, found that FDI increases CO2 emissions in East Asia countries through nonrenewable energy usage. With the use of GMM and panel Granger causality test, Shahbaz et al. (2019) discovered that the inflows of FDI into Middle East and North Africa reduces environmental quality in the region. Assi (2018) also discovered that FDI increases CO2 emissions in Ivory Coast, while Bediako et al. (2022) found that FDI significantly increases per capita CO2 emissions in west African countries, which was attributed to numerous emissions from usage of nonrenewable energy resources by multinational companies in the region.

In supporting the Pollution Halo hypothesis, other studies have found a positive relationship. These studies argue that FDI can lead to the transfer of cleaner technologies and better environmental practices through investment in clean energy and adoption of activities that support environmental cleanliness, and reducing emissions (Paramati et al., 2017). Some of these findings includes the study by Mert and Boluk (2016) who evaluated the impact of FDI and renewable energy consumption on CO2 emissions in 21 Kyoto countries using panel ARDL method. They discovered that FDI reduces environmental quality. Demena and Afesorgbor (2020) also examined these phenomena by using meta-analysis on 65 primary studies. They equally realized that FDI improves environmental quality thus validating the Pollution Halo Hypothesis. Similarly, Khan and Ahmad (2021) discovered that long-term FDI inflows increases renewable energy consumption and reduces CO2 emissions. Moreso, Twum et al. (2022) study showed that FDI inflows in SSA reduces CO2 emissions. In addition, Nihayah et al. (2022) found a negative relationship between FDI inflows and CO2 emissions in Central and Eastern European countries. This can be due to the strict environmental laws and policies implemented in the respective countries to reduce the unfavourable impacts of FDI inflows on the ecology.

Moreso, some researchers believe that the inflow of FDI will automatically be accompanied with the adoption of very modern and internationally accepted standard of compliance in operations thus leading to the consumption of clean energy since they are already used to such practices (Nyeadi, 2022). Besides, the inflow of FDI in firms make the firms more capitalised to be able to adopt best form of energy in its operations. Some empirical evidences are available to support this view. For example, Paramati et al. (2016) using 20 emerging countries tested this link. With the use of ARDL and causality test, their study established that FDI has significant positive impact on the consumption of clean energy. Again, in their work to establish the factors influencing the consumption of clean energy in 31 sub-Saharan Africa, Kwakwa et al. (2021) noted among other factors is FDI inflows into the region. Their study made use of fixed effect and random effect estimators and FMOLS.

A few studies propose a non-linear relationship. Emmanuel et al. (2023) assessed the impact of both FDI and financial development on CO2 emissions in 47 SSA countries from 1999 to 2022 by grouping the countries into different income categories. Employing the pooled mean group autoregressive distributed lags (PMG-ARDL) method, their results present long-run relationship between the variables and supports the Pollution Hallo Hypothesis. However, the heterogeneity analysis shows mixed results.

In contrast, Boamah et al. (2023) evaluated the relationship between FDI inflows, renewable energy consumption and CO2 emissions in 41 African countries from 2005 to 2019 utilizing the pooled OLS, fixed effects and random effects models, and GMM estimation techniques. Their results show that the pollution haven and halo hypothesis do no hold. Whereas FDI inflows was found to contribute to rising and falling CO2 emissions. This finding shows that FDI inflows have both deleterious and advantageous effects. This implies that FDI has in one hand promoted technological transfers from developed countries to the host country, and on the hand enhanced conventional technologies and use of unclean energy.

Some other studies emphasize the role of moderating factors such as government policies, institutions, trade and the type of FDI in influencing the FDI-Renewable energy consumption - CO2 emissions relationship. Nyeadi (2023) examined the impact of financial development and FDI on CO2 emissions and clean energy in 44 SSA countries from 1998 to 2017 using the PMG-ARDL approach. They discovered that financial development significantly reduces CO2 emissions while FDI significantly reduces it. Moreso, financial development was discovered to significantly increase clean energy while FDI has no significant relationship with clean energy adoption in the observed countries. Whereas, FDI significantly reduces clean energy and CO2 emissions in middle-income countries. Clean energy in their context is access to clean fuels and technologies for cooking. Further study can include access to clean energy for cooking while assessing the FDI inflows – renewable energy consumption relationship. In another study, Huang et al. (2022) examined the moderating role of economic development and regulatory utilizing a panel of G20 countries from 1996 to 2018, and found that FDI inflows is positively associated with CO2 emissions, while both economic development and regulatory quality were found to negatively contribute to the impact of FDI on renewable energy consumption and CO2 emissions. The implication of this study is that countries with higher levels of economic development and regulatory quality are more likely to mitigate CO2 emissions through renewable energy promotion.

These reviewed studies offer valuable insights for policymakers in Sub-Saharan African countries. They highlight the need for a balanced approach to attracting FDI while ensuring environmental sustainability through appropriate regulations and incentives. In addition, some studies introduce innovative methodologies, such as panel data analysis, to better capture the complex relationship between FDI and renewable energy consumption in the region, while some studies focus on specific sectors (e.g., extractive industries, manufacturing) to understand how FDI affects emissions differently in each sector. The current study expands the scope of research by assessing the moderating role of policies on environmental sustainability in the relationship between FDI inflows and renewable energy consumption in SSA countries.

**3. Research Method**

Upholding the pollution halo hypothesis argument, FDI inflows could instigate investment in clean energy sources and the integration of eco-friendly activities into the operational and business activities of the firm (Paramati et al., 2017). In this light, the Pollution halo hypothesis is adopted to examine the impact of foreign direct investment on renewable energy consumption in Sub Saharan African countries (Emmanuel et al., 2023; Boamah et al., 2023)

The relationship between renewable energy consumption and foreign direct investment can be expressed through a multiple linear regression model (Omri et al., 2014):

*REC= β0 + β1 FDI + β2 PS + ε* (1)

Where *REC* is renewable energy consumption which is the share of energy consumed from renewable sources in the overall energy mix, *FDI* is foreign direct investment, *PS* is policy support and *ε* is the error term. *β0* is intercept, *β1* and *β2* is the coefficient for FDI and PS.

In order to examine the impact of FDI inflows on renewable energy consumption in SSA countries, other variables including trade openness, institutional quality and environmental policies are included in the model. This study investigates the impact of FDI inflows on renewable energy consumption by observing the 48 SSA countries over the 2016 to 2022 period.

The modified model is presented below:

*RECit= β0 + β1iRECit-1 + β2iFDIit + β3iTOit + β4iINDit + β5iISTit + β6iEP+ ϑt + χi + εit* (2)

Where *REC*denotes renewable energy consumption estimated as the percentage of renewable energy consumption from total energy consumption, *FDI*denotes foreign direct investment net inflow which is the core explanatory variable and measured as a percentage of gross domestic product, *TO* is trade openness which is estimated as the sum of exports and imports of goods and services measured as a share of gross domestic product, *IND* is industrialization estimated as industrial value added as a percentage of gross domestic product, *EP* is environmental policies estimated as policies and laws on environmental sustainability, while *IST* is institutional quality.

*RECit-1* depicts the lag of renewable energy consumption included to account for the dynamic nature of the model. The subscripts *i* and *t* represent country (48) and time (7) period respectively; ϑt is the time-specific effect; χi is the country-specific effect; εit is the stochastic error term that represents all other variables that can affect economic growth in SSA but not included in the model. Moreso, *β0* is constant while *β1i*, *β2i*, *β3i*, *β4i*, *β5i* and *β6i* represent the coefficient elasticities of the explanatory variables in respect to *REC*. Trade openness was incorporated into the model because it has been discovered to have relationship with the adoption of renewable energy (Keho 2016; Amoah et al., 2023); industrial activities involving the production of goods could impact environmental quality (Amoah et al., 2023, Chen et al., 2023); institutional can influence the type of energy utilized by foreign investors quality (Hung et al., 2022).

The system generalized method of the moments (GMM) technique is employed in this study (Arellano and Bover, 1995; Arellano and Bond, 1991; Blundell and Bond, 1998), and data analyzed using STAT version 17.0.

**4. Results and Discussion**

**Table 1. Summary Statistics**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variables** | **Observations** | **Mean** | **Std. dev.** | **Min** | **Max** |
| *REC* | 263 | 62.50544 | 26.64768 | 1.21 | 97.03 |
| *FDI* | 322 | 3.497377 | 2.539579 | -18.91777 | 39.81094 |
| *TO* | 329 | 1.25414  | 1.341881  | -.0395224  | 9.677949 |
| *IND* | 308 | 24.78378 | 10.603 | 4.871401 | 57.3954 |
| *IST* | 336 | -1.08e-08 | 1.000001 | -2.523005 | 2.510399 |
| *EP* | 271 | 3.223247 | .670112 | 1 | 4.5 |

***Source: Authors’ Computation via STATA 17.0 (2024)***

From table 1, the mean, standard deviation, minimum, maximum and numbers of observation for the respective variables are displayed. As can be seen, the standard deviation of the variables is large enough to explore the variations in the data.

**Table 2. Correlation Matrix Result**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | *REC* | *FDI* | *TO* | *IND* | *IST* | *EP* |
| *REC* | 1.0000 |  |  |  |  |  |
| *FDI* | -0.1185 | 1.0000 |  |  |  |  |
| *TO* | -0.2584 |  0.3561  | 1.0000 |  |  |  |
| *IND* | 0.3443 | 0.0129 | 0.1916 | 1.0000 |  |  |
| *IST* | 0.1270 | 0.0463 | 0.2949 | -0.1834 | 1.0000 |  |
| *EP* | 0.0198 | 0.6969 | 0.2517 | 0.1903 | 0.3578 | 1.0000 |

***Source: Authors’ Computation via STATA 17.0 (2024)***

The correlation matrix shows the degree of correlation among the variables to ascertain that there is no linear dependence among the regressors in order to avoid multicollinearity. From the result, as depicted in table 2, all the regressors are not linearly dependent on one another.

**Table 3. The impact of foreign direct investment on renewable energy consumption in SSA**

|  |  |  |
| --- | --- | --- |
| **Variables** | **System GMM** | **System GMM** |
| **Column (1)** | **Column (2)** |
| *L.LnREC* | 0.9471116\*\*\*(39.15) | 0.9259683\*\*\*(1.07) |
| *FDI* | 0.0030549(1.24) | 0.021327(-0.72) |
| *FDI\*EP* |  | 0.0053858\*\*(0.81) |
| **Control Variables** |  |  |
| *TO* | 0.0014274\*(-2.62) | 0.0059662\*(1.10) |
| *IND* | 0.0043475\* (2.07) | 0.0078083\*(-0.79) |
| *IST* | 0.0275729(1.27) | 0.007988(-0.69) |
| *EP* | 0.0001232\*\*(-1.97) | 0.0002448\*(0.60) |
| Observations  | 167 | 125 |
| F Statistic | 78273.32 | 5824.49 |
| **Diagnostic tests** |  |  |
| No of Groups | 42 | 42 |
| No of Instruments | 19 | 11 |
| AR (2) p-value | 0.566 | 0.396 |
| Hansen: p-value | 0.144 | 0.126 |

Notes: \*\*\*, \*\*, \* are statistical significance at 1%, 5% and 10% levels respectively; *t-statistic* (in parenthesis) are based on white heteroscedasticity-consistent std. errors; *p-values* reported for AR (2) and Hansen statistic.

***Source: Authors’ Computation via STATA 17.0 (2024)***

From table 3, the result revealed that trade openness (0.14%), industrialization (0.43%), and environmental policy (0.012%) have statistically significant association with renewable energy consumption in SSA countries. Whereas, FDI inflows and institutional quality reported positive but insignificant association with CO2 emissions in SSA countries. Surprisingly, the system GMM estimation results shows that FDI inflows does not have a significant association with renewable energy consumption in SSA countries over the observed period. Yet, the interaction between FDI and environmental policy reports positive and significant association (0.54%) with renewable energy consumption in SSA countries. Hence trade openness and industrialization would enhance environmental quality by increasing renewable energy consumption in SSA countries. This affirms the presumption that foreign trade and rising industrial activities increases production efficiencies and adoption of modern production methods, including the use of renewable energy sources.

It could be deduced from the result of this analysis that FDI inflows alone is not sufficient in reducing increasing renewable energy consumption in SSA countries, rather FDI inflows into SSA countries coupled with strong institutions and policies on environmental sustainability could promote the use of renewable energy sources in the SSA region. The result from the system GMM estimation technique is supported by other panel data estimates presented in table 4.

**Table 4. Robustness Check (Dep. Var.: REC)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | **Pooled OLS** | **Fixed Effect** | **Random Effect** |
| *FDI* | -0.0024914(0.88) | 0.0016827(0.39) | -0.0029009(0.77) |
| **Control Variables** |  |  |
| *TO* | 0.0003176\*(-1.28) | 0.0005477(0.59) | 0.0004277\*(-1.17) |
| *IND* | 0.0001608(-0.20) | 0.0038714\*(1.67) | 0.0004987(0.48) |
| *IST* | 0.0021506(-0.28) | -0.0728874(-1.12) | 0.0011869(0.10) |
| *EP* | 0.0000328\*(-0.82) | 0.0000675\*\*(-1.03) | 0.0000421\*(-0.77) |
| Observations  | 135 | 135 | 135 |
| **Diagnostic tests** |  |  |  |
| Prob > FProb > chi2 | 0.0000 | 0.0000 | 0.0000 |
| R-squared | 0.9973 | 0.2970 | 0.9972 |
| Hausman P |  | 0.0000 |

Notes: \*\*\*, \*\*, \* are statistical significance at 1%, 5% and 10% levels respectively

***Source: Authors’ Computation via STATA 17.0 (2024)***

It was observed that the analysis of the relationship between FDI inflows and renewable energy consumption reported interesting result. FDI inflows was discovered to have no statistically significant relationship with renewable energy consumption which is supported by findings from previous studies (Ssali et al., 2019; Mahmood et al., 2020). This could be because FDI less impacts environmental laws and policies in these nations or because other variables affect renewable energy consumption more. Yet, trade was discovered to significantly improve the adoption of renewable energy sources in SSA countries, which indicates that trade partnerships among countries and regions can foster technology transfer, circular economy practices, and adoption of renewable energy resources, can encourage uniform principles in the production and consumption of goods, and contribute to lower emissions associated with resource extraction and disposal. Whereas, the interaction of FDI inflows and environmental policies was discovered to statistically increase renewable energy consumption, which implies that countries with institutions and policies supporting environmental sustainability could attract FDI inflows into countries with would embrace renewable energy consumption in SSA countries. Since industrialization was discovered to statistically increase renewable energy consumption (Amoah et al., 2023), implementing energy-efficient technologies and practices in industrial processes can help mitigate the environmental impact of industrialization in SSA countries. In addition, enacting and enforcing stringent environmental regulations and emission standards from the outset can guide industrial development in a more sustainable direction while implementing policies that incentivize cleaner production methods and penalize carbon-intensive practices can contribute to lower emissions.

**5. Conclusion and Policy Recommendations**

This study examined the impact of foreign direct investment (FDI) inflows on renewable energy consumption in Sub-Saharan African (SSA) countries, by considering the role of policies on environmental sustainability. Data of the variables for 48 SSA countries is obtained from the world bank WDI between 2016 and 2022. The result revealed that FDI has an insignificant direct relationship with renewable energy consumption, while the interaction between FDI and environmental policy increases renewable energy consumption in SSA countries. Industrialization also reported a significant determinant of renewable energy consumption. In addition, economic integration which accommodates FDI inflows and trade openness play significant roles via technology transfer and enhance adoption of renewable energy resources, which could substantially reduce CO2 emissions and enhance environmental sustainability in SSA countries.

FDI inflows and environmental policies are critical tools for reducing carbon emissions through increased renewable energy consumption. When effectively combined, they can create a supportive environment for renewable energy development, attracting investment, fostering innovation, and building domestic capacity. However, the success of these efforts depends on the consistency and clarity of environmental policies, the adequacy of infrastructure, and the careful management of social and environmental risks.

Based on the findings of this study it is recommended that the governments in SSA countries can establish targets for renewable energy adoption, such as mandating a specific percentage of energy to be sourced from renewables by a certain date. These targets provide a clear signal to investors and can encourage FDI in the renewable energy sector. Subsidies, tax breaks, and feed-in tariffs are examples of incentives that can make renewable energy projects more financially viable. By lowering the cost of renewable energy, these incentives can attract FDI and spur domestic investment in the sector. Moreso, promoting public-private partnerships can leverage public funds to attract private investment in renewable energy. These partnerships can help mitigate the risks associated with large-scale projects, making them more attractive to foreign investors.

In conclusion, strong environmental policies can increase investor confidence by providing a stable and predictable regulatory environment. For example, clear and consistent regulations on renewable energy can reduce the perceived risk of investing in these projects, attracting more FDI. Also, FDI can be directed towards achieving specific policy goals, such as increasing renewable energy capacity. For instance, foreign investors can be incentivized to invest in renewable energy projects through targeted policy measures like green bonds or special economic zones focused on clean energy. In addition, the combination of FDI and supportive environmental policies can foster innovation in renewable energy technologies. For example, policies that encourage research and development (R&D) in renewable energy can attract FDI from companies looking to innovate and expand in new markets.

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