



**DOES RENEWABLE ENERGY AND EXPORT INFLUENCE ECONOMIC GROWTH IN NIGERIA?**

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**Abstract**

*The interconnection amid renewable energy, exports, and economic growth has thus emerged as a primary policy issue. Economic theories posit that GDP is often linked to increasing emissions and exports during the initial phases of development. Sequel to this, this study examines the connection between renewable energy, export and economic growth in Nigeria using ARDL techniques over the period of 1990-2023 employing time series data from World Development Indicator (WDI, 2023). The findings indicate that there is a negative connection between renewable energy and economic growth in Nigeria. Nigeria's trade profile, as a major exporter of primary products, contributes to global emissions. However, the emphasis of this analysis is Nigeria's carbon emissions, which may decline as emissions from more environmentally friendly exports rises. The study recommended real-world policy implementation such as regulatory rigidity, limited grid capacity for renewable integration, reliance on coal in certain regions, and the political economy of energy pricing may significantly influence the feasibility of proposed interventions.*

**Keywords:** Renewable energy, export, economic growth, ARDL

**JEL Classification:** Q42, F1, 04, C5,

**1. Introduction**

The Nigerian economy has experienced significant economic and social development since early 2024, transitioning from a less regulated to a market-oriented economy and being intricately integrated into regional and global markets. This change has transformed its economic perspective and drawn significant foreign direct investment, especially in the services and export-oriented industries. Simultaneously, these advancements have exacerbated environmental pressures, particularly due to heightened energy consumption and the challenge of maintaining GDP while expediting the transition to low-carbon and renewable energy systems (Adekunle et al., 2022; Gbadebo et al., 2025; Hardi et al., 2026).

The interconnection of renewable energy, exports, and the economy has thus emerged as a primary policy issue. The Environmental Kuznets Curve (EKC) concept posits that GDP is often linked to increasing emissions and exports during the initial phases of development (Pata & Caglar, 2021). In developed and emerging economies, the move to cleaner technology and renewable energy can alleviate this link; nevertheless, the inflection point and magnitude of the effect vary by nation. In substantial open economies like Nigeria, foreign direct investment and exports are pivotal in influencing economic growth. Certain studies contend that green finance fosters economic growth and enhances export quality via technology transfer (Hua & Tong, 2026; Muhammad et al., 2026; Tansuchat & Yosthongngam, 2026), whereas others warn that foreign investment could exacerbate capital-intensive production, aligning with the pollution hypothesis (Ha et al., 2024).

Renewable energy is widely acknowledged as a crucial method for harmonizing economic development with environmental sustainability. Empirical studies in Sub-Saharan Africa (‘Dađov’a, 2023) indicate that renewable energy use might diminish emissions without compromising economic growth; nevertheless, the degree to which this is applicable in emerging economies, which largely depend on fossil fuels, remains an unresolved empirical inquiry. In Nigeria, the advancement of renewable energy has lagged that of Western nations, and the extent to which renewable energy contributes to sustained growth remains contentious (Bekun et al., 2023; Ali et al., 2026; Gyamfi et al., 2026; Sagheer & Ashraf, 2026). Notwithstanding extensive literature on economic growth, exports, and renewable energy, significant gaps persist. Most current research on Nigeria either concentrate exclusively on emissions or growth, or they employ basic classical cointegration methods that require stringent assumptions regarding the integration orders of variables. Secondly, there exists a paucity of research that integrates foreign direct investment, exports, renewable energy, and economic growth into a cohesive empirical framework for the Nigerian economy. Third, the dynamics of these relationships, specifically short-run adjustments and long-run equilibrium, have not been rigorously examined using flexible models like the Autoregressive Distributed Lag (ARDL) approach, which accommodates mixed integration orders and small sample sizes (Van et al., 2025; Van et al., 2025; Van et al., 2025).

## 2. Literature Review

Scholars have investigated the relationship between the use of renewable energy sources and economic growth. For example, Deka et al. (2024) investigated the connection between the use of biomass energy and economic development in N-11 countries using panel data from 1970 to 2017. According to their research, there is a long-term positive correlation between economic expansion and the use of biomass energy. In a similar vein, Doytch & Narayan (2016) emphasized the importance of precisely specifying technologies and assessment periods while concentrating on assessing the regional economic effects of switching to renewable energy generation. A study by Duran et al. (2024) evaluated the effects of both renewable and non-renewable energy consumption on the growth of the industrial and service industries. According to their findings, renewable energy promotes growth in dynamic industries like the manufacturing sector in middle-income nations and the services sector in wealthy economies.

Durdovic et al. (2025) examined the relationship between economic development, CO<sub>2</sub> emissions, and the usage of renewable energy in 45 sub-Saharan African nations between 1960 and 2017. They discovered a connection between the use of renewable energy and economic growth using the GMM-PVAR method. To investigate the connections between disaggregated energy consumption, economic growth, and environmental deterioration, Erdođsgan et al. (2023) used a machine learning technique. According to the studies, a reduction in CO<sub>2</sub> emissions must be complemented by greater use of renewable energy sources to guarantee steady economic growth. Eweade et al. (2023) investigated the relationship between energy usage and economic indicators in the top 10 emerging economies and G7 countries.

In Argentina, where GDP and energy use are correlated, they demonstrated this influence. They also discovered that whereas energy consumption drives GDP in Turkey, France, Germany, and Japan, the GDP drives energy consumption in Korea and Italy. Additionally, they noted that nations like Uruguay, Paraguay, Argentina, Brazil, and Venezuela have been sluggish to integrate renewable energy into their energy mix. Additionally, (Fatima et al., 2024) found a dynamic

relationship between the use of fossil fuels and renewable energy during times of reservoir scarcity in these nations.

Jouali et al., (2024) investigates "the causal relationship between economic growth and renewable energy consumption across the 28 member states of the MENA." Using data from 1995 to 2015, they emphasize bidirectional or unidirectional Granger causalities between the two macroeconomic indicators for each nation in the panel to bolster their assertion that the usage of renewable energy boosts economic growth. Similarly, (Ahmad et al., 2024) similarly uses multiple linear regression models to examine "the impact of renewable energy development in Singapore energy economy." They concluded that renewable energy sources like wind, solar, water, geothermal, and biomass can't always be employed in tandem since they compete with one another and reduce the energy economy's efficiency. In this context, three combinations of renewable energy sources have been devised to assess how the energy economy affects energy productivity and intensity. The mix of resources has been discovered to have a major impact on the energy economy's efficiency.

Between 1990 and 2018, (Rahman & Sultana, 2022) investigated "the impact of the use of renewable energy on economic growth emerging nations." They employed dynamic ordinary least squares (DOLS), completely modified ordinary least squares (FMOLS), and the heterogeneous non-causality approach. They attest to the long-term relationship between economic growth and the utilization of renewable energy. Additionally, the study found that 58% of the sample countries' economic growth is positively impacted using renewable energy, along with nonrenewable energy, capital, and labor. Using a structural vector autoregressive (SVAR) technique, (Alhashim et al., 2024) investigate "the impact of renewable energy sources on economic growth and CO<sub>2</sub>emission in E-7 nations" They concluded that, at economic costs in terms of GDP per capita, the share of renewable energy in all examined countries aside from the United States is rising. Additionally, there was a noticeable decline in CO<sub>2</sub> emissions per person. Additionally, (Y. Khan & Bounade, 2025) investigates "the effects of renewable energy consumption on economic growth of OECD countries that use renewable energy." Using panel estimating approaches, they found long-term relationships between conventional energy-related inputs and economic growth.

Khan et al., (2024) examine "the impact of renewable energy consumption on economic growth as well as the direction of causality among the major variables. They emphasized that there is no causal relationship between the factors and concluded that renewable energy has a minor negative impact on economic growth. Similarly, (Shadab & Alam, 2024) examined the effect of renewable energy consumption on economic growth between 1990 and 2019 using the Autoregression Distribution Lag and Toda-Yamamoto (T-Y) causality technique. The result shows that economic growth and renewable energy have a substantial yet short- and long-term negative relationship. (Iqbal et al., 2023) investigated nexus between carbon emission, renewable energy consumption, FDI, exports and economic growth. He highlights the substantial, if negative, relationship between long-term economic growth and renewable energy indices. He continues by saying that there were both positive and negative short-term correlations between clean energy measures and economic growth, however they were not much different from zero.

Gershon and Emekalem (2021) examine "the factors that influence the consumption of renewable energy over a 24-year span, from 1990 to 2014" using the Toda Yamamoto method. They concluded that while there is a long-term relationship between renewable energy usage and its

drivers, real income and CO2 emissions are the two primary factors impacting Nigeria's demand for imported oil products. Trade liberalization was found to have minimal effect. Additionally, the analysis showed that several of the factors impacting the consumption of renewable energy do not have a causal relationship. Nonetheless, unidirectional causality connects GDP and CO2 emissions, suggesting that fossil fuels have a significant role in real GDP or Nigeria's economic expansion. After rigorously analyzing the literature for several economic categories, this study discovered a variety of empirical perspectives on the controversy surrounding the connection between the consumption of renewable energy and economic growth. It was observed that while most of the research in Nigeria focuses exclusively on the impact of renewable energy consumption on economic growth, very few studies highlight whether the relationship between the two variables is unidirectional or bidirectional in addition to the impact of renewable energy on economic growth in the Nigerian context.

### 3. Methodology

The Solow growth model serves as the study's theoretical foundation. This model was chosen to represent the connection between Nigeria's economic growth and the use of renewable energy. The purpose of this study was to investigate the effect and connection between renewable energy consumption and economic growth in Nigeria. A linear regression model is used to create this association. To achieve the goals of this study and to capture the relationship between renewable energy consumption and economic growth in Nigeria, an econometric model was constructed in accordance with the conceptual, theoretical, and empirical literature reviewed. A few variables were added to the model as control variables, which have also been used by earlier studies to explain the effect of renewable energy consumption on economic growth [19,55]. Energy consumption is governed by a mix of exchange rate, trade openness, urbanization, and export, as explained by the functional relation and the resulting model in the implicit form in expression (1).

$$ECG = f(\text{REN}, \text{EXP}, \text{EXR}, \text{URB}, \text{TRO}) \quad \text{i}$$

ECG = Economic growth

REN = Renewable energy

EXP = Export

EXR = Exchange rate

URB = Urban population

TRO = Trade openness

Expression (1) as shown above can be modelled below

$$ECG_t = \phi_0 + \phi_1 \text{REN}_t + \phi_2 \text{EXP}_t + \phi_3 \text{EXR}_t + \phi_4 \text{URB}_t + \phi_4 \text{TRO}_t + \mu \quad \text{ii}$$

$$\begin{aligned} \Delta ECG_t = & \phi_0 + \sum_{s=1}^J \phi_{1s} \Delta ECG_{t-2s} + \sum_{s=1}^J \phi_{2j} \Delta \text{REN}_{t-s} + \sum_{s=0}^J \phi_{3j} \Delta \text{EXP}_{t-s} + \sum_{s=0}^J \phi_{4j} \Delta \text{EXR}_{t-s} \\ & + \sum_{s=0}^J \phi_{5s} \Delta \text{URB}_{t-s} + \sum_{s=0}^J \phi_{6s} \Delta \text{TRO}_{t-s} + \partial_1 ECG_{t-1} + \partial_2 \text{REN}_{t-1} + \partial_3 \text{EXP}_{t-1} \\ & + \partial_4 \text{EXR}_{t-1} + \partial_5 \text{URB}_{t-1} + \partial_6 \text{TRO}_{t-1} + \mu \dots \dots \dots \text{iii} \end{aligned}$$

$$\begin{aligned} \Delta ECG_t = & \phi_0 + \sum_s^J \phi_{1j} \Delta ECG_{t-2s} + \sum_j^J \phi_{2j} \Delta \text{REN}_{t-s} + \sum_j^J \phi_{3j} \Delta \text{EXP}_{t-s} + \sum_j^J \phi_{4m} \Delta \text{EXR}_{t-s} + \\ & \sum_m^J \phi_{5m} \Delta \text{URB}_{t-s} + \sum_m^J \phi_{6m} \Delta \text{TRO}_{t-s} + \partial_1 ECG_{t-1} + \partial_2 \text{REN}_{t-1} + \partial_3 \text{EXP}_{t-1} + \partial_4 \text{EXR}_{t-1} + \\ & \partial_5 \text{URB}_{t-1} + \partial_5 \text{TRO}_{t-1} + \epsilon \text{ECT}_{t-1} + \epsilon_t \dots \dots \dots \text{iv} \end{aligned}$$

### 4. Results and Discussion

This part presents the empirical results of the ARDL model, starting with the pre-test analysis and moving on to the ARDL limits test results, long- and short-term coefficient estimations, stability and diagnostic tests. After that, the findings are analyzed considering the corpus of research on the Nigerian context.

### **Cointegration Test**

The Cointegration test (boundaries test), which shows that the F-statistic exceeds the upper bound at a 5% significance level, confirms a long-term correlation between the parameters. Table 1 below shows the boundary test results.

Table 1: Cointegration Test (Bounds)

Test Statistic	Value	K
F-statistic	15.59502	5
<b>Critical Value Bounds</b>		
Significance	I0 Bound	I1 Bound
10%	2.26	3.35
5%	2.62	3.79
2.5%	2.96	4.18
1%	3.41	4.68

### **Long run Analysis**

ECG is positively and significantly impacted by EXP, suggesting that exports increase ECG in Nigeria. By favorably influencing change, EXP promotes economic growth in Nigeria. The positive long-term coefficient of EXP (7.6) supports export, indicating that it may be associated with industrial activity in Nigeria. This assistance may be particularly crucial for export-oriented businesses like oil and agricultural products. The negative and significant coefficient of RENEW (-7.3) supports the notion that renewables are crucial for slowing economic growth. Nigeria's recent investments in wind and solar energy infrastructure, which encourage a slowdown in economic growth (industrial heavy machine energy demand), are linked to this issue. However, EXR (-2) exhibits a strong negative correlation (-0.34), suggesting that a shift in EXR may hinder heavy technology transfer and lead to slower economic growth. It may also reflect the negative balance of payments caused by the expansion of manufacturing sector.

Although the positive long-term association between ECG and EXP may suggest the existence of a temporary growth effect in Nigeria, this conclusion is challenging due to the lack of sector-specific economic growth statistics. If economic development is concentrated in industries like mining, primary production, or heavy manufacturing, it is impossible to determine whether the manufacturing sectors are to blame for the growing impact of export and exchange rates. As a result, this study can only consider growth theory as a potential explanation rather than providing a conclusive one.

Further research is necessary considering the surprising discovery that there is a negative association between RENE and ECG in Nigeria. Although some of these emissions occur outside Nigeria's borders, it is generally accepted that Nigeria's trade profile, as a major exporter of

primary products, contributes to global emissions. However, the emphasis of this analysis is Nigeria's carbon emissions, which may decline as emissions from more environmentally friendly exports rise. One plausible hypothesis is that increased FID reduces domestic emissions per unit of output by facilitating the import of cleaner intermediate goods, encouraging efficiency gains through competitive forces, and improving access to cleaner industrial technology. Another possibility is a shift in the export mix during the study, with an increase in low-emission items or services partially offsetting the environmental impact of industrial exports.

Furthermore, renewable energy may contribute to the expansion of eco-friendly standards and technologies through integration with markets in developing countries that demand higher environmental compliance. Differentiating between the short-run and long-run impacts indicated by the ARDL model is crucial since they represent fundamentally different dynamics. The long-run coefficients, which demonstrate the long-term and consistent effects of FDI, RE, GDP, FID, and EXR on CO<sub>2</sub> emissions, represent the equilibrium interrelations that the parameters move toward over time. Conversely, the short-run coefficients demonstrate rapid or transient adaptations following shocks or changes to the explanatory parameters. It has been carefully considered if the impacts mentioned are indicative of short-term fluctuations or long-term patterns while describing the influence of factors during the investigation. This distinction is particularly crucial when talking about policy implications: long-term effects demonstrate the potential outcomes of continuing interventions or structural changes, whereas short-term impacts highlight how rapidly emissions respond to changes in the economy or energy sources.

In several significant areas, the analysis's findings both confirm and refute earlier empirical studies. For instance, earlier studies by (Ali et al., 2026; Gyamfi et al., 2026; Hardi et al., 2026) that showed GDP generates carbon emissions, especially in resource-rich economies, are supported by the positive association between GDP and emissions. However, this contradicts the EKC hypothesis, which suggests that pollution and income have an inverted U relationship. The lack of support for EKC in Nigeria, for instance, can be due to the country's resource-driven economic structure or the fact that it hasn't yet reached the critical wealth level required for environmental development (Magazzino et al., 2023). The positive relationship between FDI and emissions, which is in line with the results of (Sagheer & Ashraf, 2026; Weldengus & Berhe, 2026), supports the pollution-haven theory. However, studies like (Abid & Gafsi, 2026; Mansour, 2026) suggest that FDI could improve environmental performance and bring in cleaner technology. This issue suggests that the effect of FDI on emissions is sector-specific in Australia, where resource exploitation accounts for the majority of FDI inflows.

The negative connection is consistent with real data from studies like (Hassan et al., 2026; Lyulyov & Pimonenko, 2026) and emphasizes the potential of renewable sources in decarbonization. However, the impact appears to be moderately significant in Nigeria, possibly because of significant legislative reforms and technological investments in the renewable energy sector after 2020. The negative impact of REN is in line with the findings of Rafindadi (2025), who argued that trade might benefit the environment by reducing emissions through RE, which is in line with the notion that clean energy effectively reduces environmental harm. FID has a negative and marginally significant effect, indicating that trade dynamics in Nigeria could contribute to environmental improvement through the importation of cleaner items or the transfer of technology.

Table 2: Long run Estimate

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
ENCO(-1)	-0.112009	0.128433	-0.872124	0.4121
ENCO(-2)	0.263976	0.125677	2.100440	0.0538
ENCO(-3)	-0.011442	0.149252	-0.076660	0.9410
ENCO(-4)	-0.306789	0.134404	-2.282592	0.0564
EXPORT	7.67E-10	2.62E-10	2.929281	0.0220
EXPORT(-1)	-6.11E-10	2.11E-10	-2.900538	0.0230
EXPORT(-2)	6.41E-10	1.63E-10	3.941399	0.0056
EXR	-0.098950	0.070452	-1.404489	0.0130
EXR(-1)	-0.009855	0.044867	-0.219657	0.8324
EXR(-2)	-0.346380	0.182027	-1.902903	0.0188
EXR(-3)	0.227332	0.229177	0.991947	0.3543
RENEW	-1.711254	1.452235	-1.178359	0.2772
RENEW(-1)	-7.355068	2.824436	-2.604084	0.0352
TRO	1.22E-10	6.35E-11	1.923264	0.0959
TRO(-1)	4.60E-10	7.01E-11	6.555057	0.0003
TRO(-2)	3.99E-10	9.89E-11	4.035699	0.0050
TRO(-3)	2.93E-10	9.66E-11	3.033641	0.0190
UPO	-319.9303	157.6721	-2.029086	0.0820
UPO(-1)	542.1840	330.3608	1.641187	0.1448
UPO(-2)	-297.6935	176.1407	-1.690090	0.1349
UPO(-3)	72.86387	34.78677	2.094586	0.0745
C	1116.891	242.6928	4.602077	0.0025
R-squared	0.985703	Mean dependent var		134.5522
Adjusted R-squared	0.942812	S.D. dependent var		28.85637
S.E. of regression	6.900716	Akaike info criterion		6.796983
Sum squared resid	333.3392	Schwarz criterion		7.834242
Log likelihood	-76.55626	Hannan-Quinn criter.		7.121840
F-statistic	22.98158	Durbin-Watson stat		2.315133
Prob(F-statistic)	0.000148			

**Short run Analysis**

Short-term fluctuations (ECM Model): Table 3 displays the short-term coefficients and error correction term (ECT). The statistically significant negative ECT indicates that departures from the long-term equilibrium are corrected by around 115% annually. The error correction term's negative and significant value of 1.15 indicates a moderate pace of adjustment to long-term equilibrium.

Table 3: Short-run Analysis

Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.

D(ENCO(-1))	0.054255	0.112254	0.483321	0.6436
D(ENCO(-2))	0.318231	0.155258	2.049686	0.0796
D(ENCO(-3))	0.306789	0.134404	2.282592	0.0564
D(EXPORT)	0.000000	0.000000	2.929281	0.0220
D(EXPORT(-1))	-0.000000	0.000000	-3.941399	0.0056
D(EXR)	-0.098950	0.070452	-1.404489	0.2030
D(EXR(-1))	0.346380	0.182027	1.902903	0.0988
D(EXR(-2))	-0.227332	0.229177	-0.991947	0.3543
D(RENEW)	-1.711254	1.452235	-1.178359	0.2772
D(TRO)	0.000000	0.000000	1.923264	0.0959
D(TRO(-1))	-0.000000	0.000000	-4.035699	0.0050
D(TRO(-2))	-0.000000	0.000000	-3.033641	0.0190
D(UPO)	319.93028	157.672109	-2.029086	0.0820
D(UPO(-1))	297.69352	176.140658	1.690090	0.1349
D(UPO(-2))	72.863872	34.786765	-2.094586	0.0745
CointEq(-1)	-1.166264	0.141330	-8.252036	0.0001

### Diagnosis Test

The diagnostic test results are shown in Table 4, Table 5, and Figure 1. The time series data shows no signs of heteroskedasticity, serial correlation, or issues with model specification. On the diagnostic problem, however, the investigation refuted the null hypothesis. The CUSUM and CUSUM square show that the model structure is still stable, as seen in Figures 1 and 2.

Table 4: Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	6.864041	Prob. F(2,5)	0.0368
Obs*R-squared	21.25762	Prob. Chi-Square(2)	0.0000

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.882861	Prob. F(21,7)	0.6194
Obs*R-squared	21.05171	Prob. Chi-Square(21)	0.4558
Scaled explained SS	1.599890	Prob. Chi-Square(21)	1.0000

Figure 1: Cusum

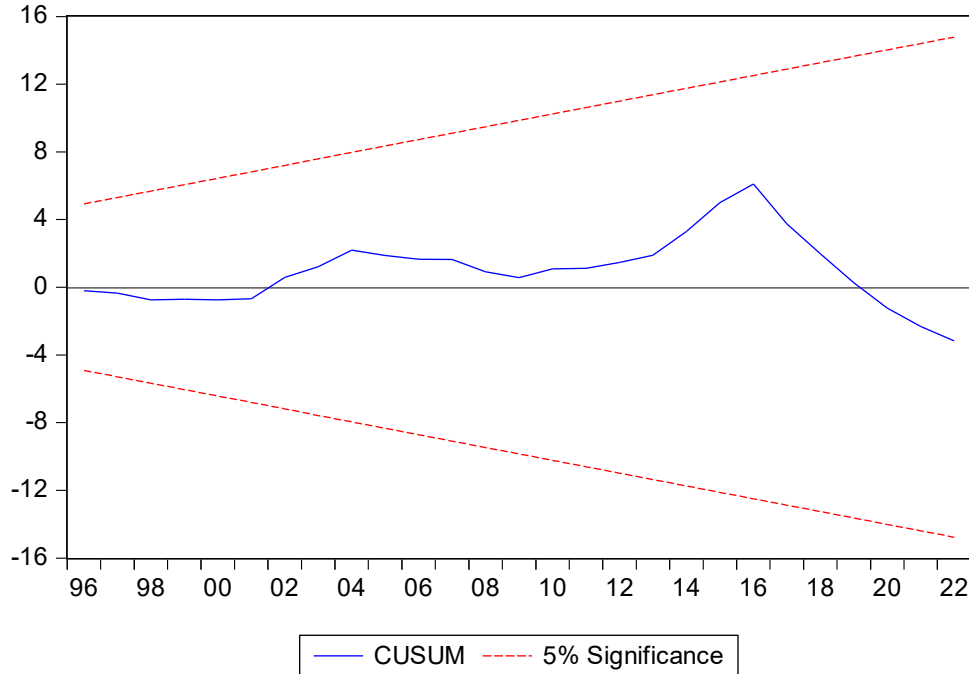
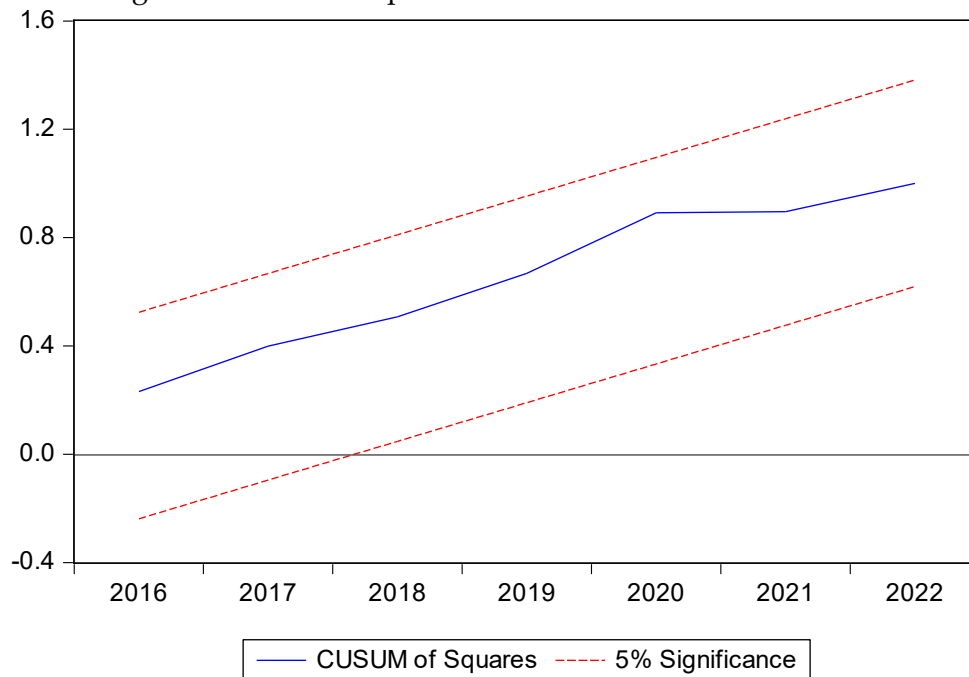


Figure 2: Cusum of Squares



### 5. Conclusion and Recommendations

According to the report, a country's carbon emissions are greatly impacted by renewable energy, especially solar and wind power, in terms of installed capacity and electricity production. Hydropower generation has no effect on emissions, but its installed capacity does. Remarkably, emissions levels are unaffected by a nation's GDP or the existence of a carbon tax. Some countries are still in transition, possibly since there are still very few nations in the globe who have adopted

this carbon price policy. These results highlight how crucial renewable energy is to reducing carbon emissions. As a result, adopting renewable energy should be a top priority for all nations. These findings' positive and negative ramifications can help governments and the energy sector set the best boundaries for renewable energy to guarantee their contribution to sustainability. To mitigate carbon emissions and address global warming, effective legislative measures and international cooperation are required.

The policy recommendations presented in the study remain broad and generic, offering limited engagement with the practical constraints, institutional barriers, and country-specific trade-offs that shape real-world policy implementation such as regulatory rigidity, limited grid capacity for renewable integration, reliance on coal in certain regions, and the political economy of energy pricing may significantly influence the feasibility of proposed interventions. Without considering these institutional realities and structural constraints, the policy implications risk being overly idealistic and may not adequately reflect the challenges policymakers face in operationalizing green growth strategies.

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