

The Impact of Renewable Energy Consumption and Public Capital Expenditure on Poverty Reduction in Nigeria

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Abstract

Poverty has been an important issue of discussion in underdeveloped countries and has been of crucial concern to many stakeholders across the globe. This article examines the extent to which renewable energy consumption and public capital expenditure impact the poverty rate in Nigeria over the period 2003 - 2019. We employed cointegration and Autoregressive Distributed Lag (ARDL) bounds model for our analysis. Our results revealed that renewable energy consumption significantly escalates poverty in the short run. Public capital expenditure, economic growth, and governance quality substantially reduce Nigeria's poverty. The long-run analysis reveals that renewable energy consumption significantly elevates Nigeria's poverty rate in the long run. Moreso, economic growth and quality of governance reduce the poverty rate substantially, whereas public capital expenditure does not significantly reduce the poverty rate in Nigeria in the long run. The Nigerian government was recommended to adopt modern renewable sources through a public-private partnership and promote good governance, especially in the efficient and appropriate implementation of public capital expenditures.

Keywords: Renewable Energy Consumption, Public Capital Expenditure, Poverty, Human Development Index.

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1. Introduction

Globally, there has been increasing attention and literature on poverty and the state of living standard of people. It has been argued that economic growth and increased production activities could reduce the poverty rate in underdeveloped nations (Department for International Development [DFID], 2002). This notion is also supported by the vicious circle of poverty concept

postulated by Nurkse (1953), which illustrates that poor economies remain poor due to low income, which reduces their purchasing power and savings, leading to low capital formation and low productivity. This scenario will eventually lead to a low-income generation and the cycle will continue, leaving poor economies in a perpetual state of poverty (Hashim et al., 2016; and Bass, 2011).

Energy is perceived as a vital element for production and is subsequently important for economic growth and development (Alaali et al., 2015). Energy is crucial for sustainable development and poverty eradication and fossil fuels will continue to take a larger portion of total energy use in decades (The United Nations Commission on Sustainable Development [UNCSD], 2007). There are debates on the environmental consequences of conventional energy usage due to its creation of CO₂ emissions, which contribute to global warming (Balsalobre-Lorente et al., 2018; Adu & Denkyirah, 2019). These consequences have led to the promotion of environmentally friendly renewable energy sources. Sub-Saharan African (SSA) countries are recently adopting innovative technologies for renewable energy utilization (Asongu et al., 2019). However, renewable energy technologies, including Nigeria, still account for only a small fraction of total energy use in this region.

Keynes' popularization of the critical relevance of government intervention in the economy to provide social benefits for poverty reduction has increased government provision of infrastructural facilities such as roads, irrigation, electricity, healthcare facilities, transportation and communication networks. These governments' intervention tends to equalize opportunities to reduce poverty. Surprisingly, according to the (Central Bank of Nigeria [CBN], 2019), Nigeria's public capital expenditure increased considerably over time, amounting to N 2288.996 billion in 2019, yet the country's poverty rate, as reported by the Nigerian Bureau of Statistics for 2019 was as high as 40% as the World Bank reports that 4 in every 10 Nigerians are below the poverty line in 2022. Furthermore, there are arguments that one of the panaceas to meeting a country's socioeconomic development is government participation through intensive capital projects. Lam and Law (2018) identified the significance of public expenditure as an economic and social intervention to increase the economy's production capacity. Similarly, Muritala and Taiwo (2011) concluded that capital expenditure promotes economic growth in developing countries.

A series of measurements used to explain the economic growth and development level include GDP, GDP per capita and welfare. Social indicators have been identified as a better measure of basic needs for economic development because they can be used to measure deprivations. Furthermore, these social indicators centre on alleviating poverty by providing basic needs to the less privileged (Jhingan, 2012). Hicks and Streeten (1979) identified health, education, food, water supply, sanitation and housing as six social indicators for basic needs. There have also been human development indices like the physical quality of life index (PQLI) proposed by Morris in 1979 and the human development index (HDI) by Desai and Sen in 1990.

As we explore the extent to which public capital expenditure and renewable energy consumption reduce the poverty rate in Nigeria, poverty reduction is proxied with HDI in this study. More importantly, this study examines the extent to which the Nigerian government's attitude towards capital expenditure and renewable energy consumption has reduced poverty in the country.

Based on the Robert Solow growth theory propounded in 1956, economic growth is a result of improvement in labour, capital and state of technology, while the Keynesian theory emphasizes the role of public expenditure in boosting the economy and reducing poverty level (Mathew et al., 2019) by injecting public expenditure into the economy. In like terms, Lam and Law (2018) emphasized the relevance of the government in providing financial support to achieve economic growth.

The energy transition theory, having linked energy consumption with poverty, proposed that energy is crucial for production and income generation, without which the levels of economic activities are limited (Kaygusuz, 2011; Sovacool, 2012; Okwanya & Abah, 2018). The energy transition theory is also used to explain the situation of economies moving from reliance on fossil fuels and other non-renewable energy sources to economies relying on renewable energy sources. Previous scholars have noted that many countries have been pursuing policies of transitions to a cleaner, renewable energy (Berkhout et al., 2012) as they strive for economic growth and development without neglecting environmental consequences.

There are propositions for measuring the level of poverty in an economy, one of which is the human development index (HDI). The HDI was postulated by Meghnad Desai and Amartya Sen in 1990 postulated. It is an index of social indicators across four dimensions which measures health, literacy and income level. HDI is a measure of average accomplishment across socio-economic indicators (United Nations Development Programme [UNDP]). The UNDP has since 1990 been presenting the HDI as the average measurement of human development.

To construct the HDI, Desai and Sen, 1990 first created the index for the dimensions: Life Expectancy Index, Education Index and GDP Index. The HDI is then derived by finding the average of the three indices.

Table 1. The HDI Estimation Criteria

Indicators				Maximum Value	Minimum Value
Life Expectancy at Birth (years)				85	25
Education Index	Adult Literacy Rate in percentages			100	0
	Combined Gross Enrolment Ratio in percentages			100	0
GDP Per Capita (PPP in US Dollars)				40,000	100

Source: Jhingan (2012)

Measuring a country by accomplishments in healthcare, level of education and income level can give a clearer view of the level of development in a country (Jhingan, 2012), thus can be used to measure the poverty level of a country. In this case, a high HDI value implies improved welfare and less poverty, while a low HDI implies a high poverty rate.

In the present study, while adopting the Solow and Keynesian growth model and the energy transition theory, poverty is proxied with HDI as the tendencies of public capital expenditure and renewable energy consumption in reducing poverty in Nigeria over the period 1981 – 2021 is investigated.

2. Literature Review

In this study, the empirical literature review is in two strands; In contrast, the first review is past literature on the public expenditure-poverty nexus, and the second focuses on the renewable energy consumption-poverty relationship.

2.1 Renewable Energy Consumption and Poverty Nexus

Studies on the relationship between different energy sources and other variables started with the work of Kraft and Kraft in 1978. They argued that energy was one of the essential drivers of modern growth. Since then, many other researches have been carried out on the relationship between energy consumption and other macroeconomic variables. Particularly, there have been studies that investigated the relationship between renewable energy consumption and economic growth in multiple countries (Maji, 2015; Belaid & Youssef, 2017; Bhattacharya et al., 2016; Maji, 2017; Narayan & Doytch, 2017; Balsalobre-Lorente et al., 2018; Silva et al., 2018; Maji et al., 2019; Nguyen & Kakinaka, 2019) and individual countries (Jebli & Youssef, 2015; Dogan, 2016; Boontome et al., 2017; Cherni & Jouini, 2017; Lotz & Dogan, 2018; Pata, 2018; Sarkodie & Adams, 2018). Results revealed a positive relationship between the variables (Jebli & Youssef, 2015; Bhattacharya et al., 2016; Lotz & Dogan, 2018; Pata, 2018; Silva et al., 2018). Some reported significant negative relationships (Nguyen & Kakinaka, 2019), while a few found no significant relationship between the variables (Dogan, 2016).

There is a need for an updated study of the relationship between renewable energy consumption and poverty rate, especially on the extent to which poverty rate in low income countries can be reduced through the adoption of renewable energy sources. Nevertheless, Meikle and Bannister (2003) evaluated the relationship between energy consumption and the poverty rate in Indonesia, Ghana and China, discovering that the less privileged are more vulnerable to shocks in the energy market. Investigating the relationship between energy consumption, electricity consumption and human development index across 15 developing countries between 1988 and 2008, Ouedraogo (2013) discovered that in the short-run no causal link exist between the variables. At the same time, the long-run result shows a negative causality from energy consumption to HDI and a positive causality from electricity consumption to HDI. Gertler et al. (2011) examined the relationship between the rate of poverty, economic growth and energy demand and found that pro-poor countries have a higher demand for energy than those that are not. Okwanya and Abah (2018) examined the relationship between energy consumption and poverty rate in 12 African countries from 1981 to 2014. They employed the fully modified ordinary least squared method and discovered long-run negative relationship between energy consumption and poverty level. They also noted that capital stock and political stability significantly reduce the poverty level in sample countries.

2.2 Relationship between Public Capital Expenditure and Poverty

Lupu et al. (2018) examined the relationship between various categories of government expenditure on GDP in 10 Central and Eastern European countries using quarterly data for 1995-2015 and the ARDL model. They discovered that government spending on certain categories like education and health improves economic growth. In contrast, government spending on other sectors of the economy, rescues economic growth in the observed countries. Udonwa and Praise (2018) assessed the impact of government expenditure on poverty in Nigeria over the period 1970

to 2014 using the ARDL technique. Their results revealed that the government's recurrent expenditure on administration reduced poverty while its recurrent expenditure on social and community services increased Nigeria's poverty rate. Their result also shows that government capital spending on economic, social and community services reduced poverty while capital expenditure on transfers increased the poverty rate in Nigeria within the observed period. They recommended efficient and adequate implementation of planned capital expenditures with a reduction in recurrent spending. Similarly, Adegboyo (2020) analyzed the impact of public spending expenditure on the poverty rate in Nigeria for the period 1981 - 2017 using the ARDL model. His finding revealed that recurrent government expenditure on economic, social and community service and transfer reduces the poverty rate, while government capital expenditure on transfer and administrative services increases poverty in the country.

Omodero (2019) investigated the impact of public sectorial expenditure on poverty reduction from 2000 to 2017 in Nigeria. The researcher employed the OLS estimation method and found that public expenditure on various sectors significantly reduce poverty rate. The researcher recommended sufficient allocation of government expenditure to the identified sectors to ensure improvement in their productivity, which should invariably alleviate poverty.

Joy et al. (2021a) evaluated public spending's impact on Nigeria's poverty rates from 1981-2015. Using the ARDL model, they discovered that public capital expenditure significantly increases the poverty rate in Nigeria. The researchers opined that inefficient government spending on capital projects could account for their results. Similarly, Joy et al. (2021b) examined Nigeria's public capital expenditure and her economic development nexus over the period 2008 - 2015 using the ARDL method. Their results show that public capital expenditure significantly reduced economic development in Nigeria and recommended that government capital expenditure be used appropriately to yield the economic development desired. Hidalgo-Hidalgo and Iturbe-Ormaetxe (2018) studied Europe's public expenditure's impact on poverty reduction among adults. The study covered 2005 to 2011 and found that public expenditure on education significantly reduced the incidence of poverty among adults. Dimnwobi, Onuoha, Uzoechina, Ekesiobi, and Nwokoye (2022), with evidence from Nigeria, investigated if public capital expenditure reduced energy poverty between 1990 to 2020. Using the ARDL method, they discovered that government capital expenditure negatively impacts access to energy in Nigeria which translates to reduced access to urban electrification and renewable energy generation and consumption while insignificantly improving rural electrification. Their results also show that an increase in energy prices would lead to improvement in energy access which would translate to rural and urban electrification and more generation and consumption of clean energy.

Related studies carried out in the past have focused on the energy-poverty relationship or public capital expenditure-poverty relationship. The current study, however, concentrates on the public capital expenditure-renewable energy consumption-poverty relationship and uses the HDI as a proxy for the poverty rate.

3. Research Methods

Relying on the Solow and Keynesian growth models, we recognized the importance of public capital expenditure in determining the country's poverty level. In addition, the energy transition theory helped us identify the likely link between energy consumption and poverty via income level.

However, some recent transition studies opined that other factors like political, institutional and socio-cultural changes are important influencers of sustainable development, consequently, poverty reduction (Berkout et al., 2009). As a result, apart from renewable energy consumption, we also included GDP and quality of governance as determinant variables of poverty in our study.

This study adopted the model Okwanya and Abah (2018) used in a related study by replacing energy consumption with renewable energy consumption, a capital stock with public capital expenditure and political stability with quality of governance. The modified model adopted in this study is presented below:

$$\text{Pov} = f(\text{PCE}, \text{REC}, \text{GDP}, \text{QG}) \dots \dots \dots (1)$$

Where Pov denotes poverty, F is the functional relationship, PCE, REC, GDP, and QG represents public capital expenditure, renewable energy consumption, gross domestic product and quality of governance, respectively. The quality of governance variable was estimated by finding the mean of four dimensions as noted in table 2 below.

Table 2: Variables and Sources

Variable Name	Notation	Estimations	Data Source
Poverty	Pov	Human Development Index	UNDP
Government Capital Expenditure	PCE	Government capital expenditure in (₦' Billion)	CBN
Renewable Energy Consumption	REC	% share of renewable energy in total energy consumption	WDI
Economic Growth	GDP	Gross Domestic Product Per Capita (2015 constant US\$)	WDI
Quality of Governance	QG	i. Political Stability and Absence of Violence/Terrorism ii. Regulatory Quality iii. Rule of Law	ESG

UNDP: United Nations Development Programme; WDI: Word Development Indicators; CBN: Central Bank of Nigeria; ESG: Environment Social and Governance.

Source: Authors' Compilation, 2022.

The model is specified in its explicit form to reflect the time series nature of the variables as below:

$$\text{Pov}_t = f(\text{REC}_t, \text{PCE}_t, \text{GDP}_t, \text{QG}_t) \dots \dots \dots (1)$$

$$\text{Pov}_t = \alpha_0 + \alpha_1 \text{REC}_t + \alpha_2 \text{PCE}_t + \alpha_3 \text{GDP}_t + \alpha_4 \text{QG}_t + \varepsilon \dots \dots \dots (2)$$

α_0 is constant; α_1 , α_2 , α_3 and α_4 are the coefficients of lung-run elasticities associated with the explanatory variables; ε is the error term.

All variables in the model were converted into a logarithm linear econometric model to reduce skewness in the time series data (Maji, 2015), which is presented below.

$$\text{Pov}_t = \alpha_0 + \alpha_1 \ln \text{PCE}_t + \alpha_2 \ln \text{REC}_t + \alpha_3 \ln \text{GDP}_t + \alpha_4 \ln \text{QG}_t + \varepsilon \dots \dots \dots (3)$$

The first step was establishing whether the variables have unit roots by conducting the stationarity test using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. Next was to test for cointegration among the variables of interest.

4. Results and Discussion

This study examined the empirical impact of renewable energy consumption and public capital expenditure in Nigeria. The annual data were obtained in 2022 from the World Bank's world development indicator (WDI), the Central Bank of NigerCentral Bank of Nigeria (CBN) statistical bulletin and Environment Social and Governance (ESG). The collected data were for 2003 to 2019 due to availability.



Fig. 1. Variables trend. Source: WDI (2022)

Table 3: Description of variables.

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Variables	ln Pov _t	ln REC _t	ln PCE _t	ln GDP _t	ln QG _t
Mean	-0.698008	4.430337	6.705871	7.745618	-1.306306
Median	-0.709277	4.430936	6.773881	7.809681	-1.287277
Maximum	-0.618040	4.485034	7.735869	7.896652	-1.226388
Minimum	-0.798508	4.389995	5.487649	7.475166	-1.504243
Std. Dev.	0.057682	0.027090	0.538048	0.132932	0.073501
Skewness	-0.128241	0.435189	-0.395447	-0.693826	-1.399735
Kurtosis	1.703299	2.147186	3.351744	2.151181	4.390706
Jarque-Bera	1.237611	1.051769	0.530709	1.874300	6.921192
Probability	0.538587	0.591032	0.766934	0.391743	0.031411
Sum	-11.86614	75.31573	113.9998	131.6755	-22.20721
Sum Sq. Dev.	0.053236	0.011742	4.631932	0.282735	0.086437
Observations	17	17	17	17	17

Source: Authors' computation (2022)

The result of Jarque-Bera reflects the normal distribution of all variables used in the model.

Table 4: Stationary test result.

Variables	ADF		PP	
	Level	First difference	Level	First difference
ln Pov _t	-1.220903(0.638)	-3.959148(0.011)***	-1.220903(0.638)	-3.959148(0.011)***
ln REC _t	-1.027746(0.716)	-3.959148(0.014)***	-1.066725(0.702)	-3.959148(0.014)***
ln PCE _t	-2.701103(0.056)*	-1.811646(0.358)	-1.650207(0.436)	-3.959148(0.021)***
ln GDP _t	-1.576135(0.470)	-1.639003(0.440)	-2.673460(0.056)*	-1.595133(0.461)
ln QG _t	-3.920350(0.049)***	-4.004425(0.000)***	-2.673460(0.051)*	-3.959148(0.000)***

*** indicates 1% significance level while * indicate 10% significance level.

Source: Authors' computation (2022)

The result of Jarque-Bera reflects the normal distribution of all variables used in the model. The stationarity of the variables was tested with the unit root tests of Augmented Dickey-Fuller (ADF) and Phillips Perron (PP). The stationary test result is depicted in the above table and suggests that the variables were stationary at I (0) or I (1). This indicates that the autoregressive distribution lag (ARDL) test is appropriate for estimating the long-run relationship among the variables.

Table 5: Result of ARDL cointegration test

Pov _t = f(REC _t , PCE _t , GDP _t , QG _t)		Sig. level	Critical values for bound test: Case III	
F-statistics			Lower bounds	Upper bounds
(12.14202)***		1% level	3.29	4.37
Lag length		5% level	2.56	3.49
(1,1,1,0,1)		10% level	2.2	3.09

***Indicates 1% significance level

Source: Authors' computation (2022)

Since the variables are stationary at levels and first difference, the appropriate cointegration test is the ARDL bounds test proposed by Pesaran et al. (2001). The ARDL bound test null hypothesis is that no cointegration exists in the equation, while the alternative hypothesis is that cointegration exists in the equation. The F-statistic value ascertains the ARDL bound test position. If it is greater than the critical value for the upper bound, then cointegration exists, meaning a long-run relationship exists among the variables. Further analysis would be to estimate the long-run model by conducting the ARDL and error correction model. On the other hand, a greater If the value of the calculated F-statistic is below the critical value for the lower bound, it can be concluded that cointegration and the long-run relationship do not exist. In such a situation, only the short-run model would be estimated, which is the ARDL model without the error correction model.

The ARDL cointegration test result is presented in Table 5. It shows that cointegration exists since the F-statistics value (12.14202) is greater than the value of the upper bounds (4.37) at a 1% significance level. It became imperative to conduct the long-run and short-run relationship among the variables using the ARDL and error correction model (ECM).

Table 6: Estimated long-run and short-run coefficients.

Dependent variable = $\ln \text{Pov}_t$				
Long-run results			Short-run results	
Variables	Coefficient	T-ratio (p values)	Coefficient	T-ratio (p values)
$\ln \text{REC}_t$	-0.883180	-7.955771(0.000)	-0.395970	-4.947036(0.002)
$\ln \text{PCE}_t$	0.015731	1.367971(0.214)	0.034058	6.520005(0.000)
$\ln \text{GDP}_t$	0.203592	4.813400(0.002)	0.137295	4.053763(0.005)
$\ln \text{QG}_t$	0.239121	2.998911(0.020)	0.038227	2.341433(0.052)
Constant	1.848377	2.413374(0.047)	1.246479	8.473983(0.000)
ECM (-1)			-0.674364	-8.416634(0.000)

Source: Authors' computation (2022)

Having established cointegration among the variables, the long-run and short-run models were determined, as depicted in Table 6 above. Based on the long-run ARDL analysis, there exists a significant relationship between poverty reduction and renewable energy consumption, economic growth and quality of governance, whereas there is no significant relationship between poverty reduction and public capital expenditure. The long-run coefficient of renewable energy consumption is negative and significant, while that of economic growth and quality of governance is positive and significant. In contrast, the long-run coefficient of public capital expenditure is positive but not insignificant.

More so, the long-run analysis revealed that renewable energy consumption has an inverse relationship with poverty reduction in Nigeria. A 1% increase in renewable energy consumption increases poverty by 0.8832%, other determinants of poverty held constant. This result is not far from the reality since Nigeria is still in the early stage of renewable energy consumption and has yet to utilize available renewable energy sources fully. Moreover, biomass still constitutes a larger portion of renewable energy sources in the country. Also, the coefficient of economic growth is

significant at 1% and has a positive long-run relationship with poverty reduction in Nigeria. This result implies that a 1% increase in economic growth reduces poverty by 0.2036%.

Similarly, the coefficient of governance is positive and significant at a 1% level, implying that a 1% improvement in the quality of governance reduces poverty by 0.2391%. Therefore, the government should promote the rule of Law and regulatory controls. More so, the government, at various levels, should put in place measures to prevent and reduce violence and terrorism in the country. On the other hand, the estimate of public capital expenditure and poverty reduction is positively but insignificantly related in Nigeria. This means that a 1 % increase in public capital expenditure reduces poverty by 0.0157% but insignificantly.

The estimated short-run relationship was also presented alongside the long-run results in Table 6. The result revealed that the coefficient of all variables is significant at the 1% level. All variables except renewable energy consumption positively relate to poverty reduction in the short run. The short-run coefficient of renewable energy consumption is -0.39597, which means that a 1% raise in renewable energy usage increases poverty by 0.3960%. More so, the result shows that a 1% increase in public capital expenditure reduces poverty by 0.0341%, while a 1% increase in economic growth also reduces poverty by 0.1373%, and a 1% increase in quality of governance leads to poverty reduction by 0.03823%. In addition, the coefficient of the ECM is negative and significant. The ECM result shows a high speed of adjustment from the short to the long run. If there is any disequilibrium in the system, it takes an average speed of approximately 67.44% to adjust back from the short to the long run.

The diagnostics tests were further conducted to ascertain the reliability and stability of the results. The model's reliability was tested for serial correlation, normality and heteroscedasticity. The result of the diagnostic test is presented in Table 7 and shows that the model passes the three diagnostic checks with p-values higher than 0.05. The stability of the model was tested by conducting the cumulative sums of recursive residuals and the square of recursive residuals. The results were presented in Fig. 2 and Fig. 3, depicting that the statistics fall within the acceptable critical bounds at a 5% significance level, which implies that the model is stable and consistent.

Table 7: Diagnostic tests results.

	F-statistics	P values
Serial correlation	0.764949	(0.5130)
Normality	0.723619	(0.6964)
Heteroscedasticity	1.659938	(0.2591)

Source: Authors' computation (2022)

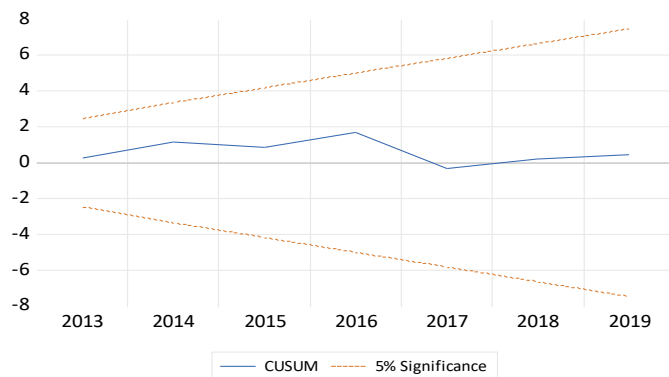


Fig. 2: Cumulative sum of recursive residuals

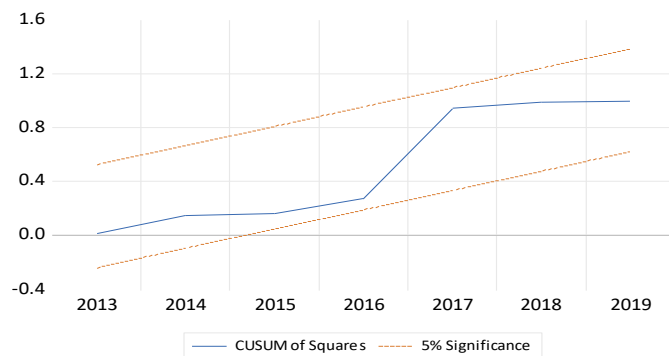


Fig. 3: Cumulative sum of squares of recursive residuals

Source: Extract from *E-views 10* (2022)

5. Conclusions

This study examined the impact of renewable energy consumption and public capital expenditure on poverty reduction in Nigeria from 2003 to 2019. The ARDL bound tests revealed that long-run cointegration exists among the variables and makes it imperative to conduct the long-run and short-run relationship between the dependent and independent variables using the ARDL and error correction model (ECM) estimation technique. The long-run result revealed that renewable energy consumption significantly increases poverty, while economic growth and governance quality significantly reduce it. In addition, public capital expenditure does not significantly impact the poverty rate in Nigeria in the long run. This is linked to past results (Udonwa & Praise, 2018; Omodero, 2019; Adegboy, 2020; Joy et al., 2021a), which show inefficiencies in the implementation of government capital expenditure. The short-run result revealed that renewable energy consumption, public capital expenditure, economic growth and quality of governance significantly impact the poverty rate. While renewable energy consumption significantly increases the poverty rate, other variables reduce it in the short run in Nigeria.

It is recommended that the Nigerian government adopt policies to promote modern renewable energy sources through investment in renewable energy technologies and partnerships with private stakeholders. The government should promote good governance and the rule of Law, which would

ensure a conducive business environment and enable citizens to engage in economic and income-generating activities. In addition, the government should ensure efficient implementation of budgeted capital expenditure through monitoring and preventing corruption, which could impede the appropriate capital expenditure implementation in the country.

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