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Impact of Electricity Power Consumption on Economic Growth in Nigeria: A Threshold Regression Analysis Approach

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ABSTRACT

Despite the abundance of several electricity sources in Nigeria and Government efforts in attracting private sector investment over the last two decades, the country is still facing several challenges which includes investment, electricity generation, transmission, distribution, and labour related issues that has contributed to dwindling economic fortunes. Therefore, this paper investigated the relationship between electricity power consumption and economic growth in Nigeria from 1990 to 2022. The paper employed a Threshold Regression Approach. The results revealed that the paper observed a negative relationship with economic growth in the regime characterized by low electricity power consumption values of -0.2381. Conversely, higher electricity power consumption values of 0.2556 established a positive relationship in the regime. These findings underscored a nonlinear relationship between economic growth and electricity power consumption following the endogenously determined threshold value of 0.1301. The study's implications for policy and investment decisions in Nigeria are profound. The results highlighted the critical role of electricity power consumption growth in shaping economic growth. Policymakers and stakeholders are urged to consider initiatives promoting the expansion and modernization of the power sector, involving infrastructure investment and attracting private sector involvement. Moreover, recognizing the positive influence of labor force growth values of 0.2670 on economic growth, there is an opportunity to harness Nigeria's abundant labor force. Policy recommendations include a focus on workforce development, education, and training to enhance the skills and productivity of the labor force. In light of the non-significant impact of investment growth (-0.0025) on economic growth, a re-evaluation of privatization efforts in the power sector is recommended. Policymakers should prioritize attracting meaningful investments directed at power sector infrastructural development and create an environment conducive to private sector participation, fostering sustainable economic growth in Nigeria.

Keywords: Economic Growth, Electricity Power Consumption, Threshold Regression, Nonlinear, and Nigeria

JEL: G15, O16, Q48, L94 and C30

INTRODUCTION

Globally, the power sector has been undoing rapid transformation, influenced by the growing demand for electricity, the increasing need for cleaner and more sustainable electricity sources, policy and regulatory changes, rapid technological advancements, population growth, urbanization and economic development. Emerging economies like Nigeria are increasingly experiencing a surge in electricity demand as the country strives to improve living standards and industrialize the nation. The empirical investigation has taken center stage due to inadequate literature on the theory of growth energy in recent times; Ozturk and Acaravci (2011) revealed that electricity consumption could support economic growth as production activities require electricity as a crucial engine of growth. Li et al. (2018) suggested that economic growth depends on energy input. They opined that electricity consumption could promote the production of capital, labor, and technology, thereby increasing economic production. However, the increasing energy consumption, particularly nonrenewable energy consumption, has thwarted sustainable economic development due to environmental degradation, Zhang et al., (2017). Electricity is the central infrastructure to facilitate community activities to be more efficient and increase economic growth (Adom, 2011; Ibrahiem, 2015; Sarkodie & Adams, 2020). Advances in technology and infrastructure facilitate modern human life.

Ibrahiem (2015) and Sarkodie & Adams (2020) stated that the availability of electricity as a resource has a broad impact on production, trade, schools, and hospitals and improves public services. Industrialization requires a power supply. Based on research findings in various countries, electrical energy has a positive impact on driving the economy. According to Neo-Classical economists, energy can stimulate economic growth, especially in the manufacturing and industrial sectors. According to Mahfoudh and Amar (2015) and Adams et al. (2020), the development of electrical energy can stimulate the African economy.

On the other hand, a shortage of electricity supply causes an economic slowdown. Thus, obstruction of the electricity supply can cause losses to the industrial sector. Community activities become more effective with electrical energy, especially in developing countries like Nigeria.

Nigeria is one of the leading economies in Africa, and production activities are highly dependent on electricity. The expansion of Nigeria's economy is triggered by rapid industrialization, agricultural modernization, information technology, financial development, and urbanization; all of these are highly dependent on electricity. In the literature, electricity consumption and growth nexus have been studied using several methods and techniques in different countries with different scopes and time series data, giving mixed results.

There has been a significant and rapid shift towards renewable energy sources, driven by the need to reduce greenhouse gas emissions and mitigate climate change. In particular, solar and wind energy have been remarkably affected in growth due to declining costs, improved efficiency, and global supportive policies, which set ambitious global renewable energy targets and invest heavily in renewable power generation. This is also evident in the decentralization and the rise of distributed electricity resources such as rooftop solar panels, electricity storage systems and microgrids. These enhanced technologies allow for localized electricity generation, consumption, storage and distribution, ultimately reducing reliance on centralized power plants and enhancing grid resilience. Despite the staggering energy mix, Nigeria’s policies, programmes and investment efforts has not yielded significant improvement in its quest for rapid industrialization. Nigweria with an estimated population of over 220 million citizens, the total number of electricity consumers in the Q4 2023 stood at 12.12 million (NBS,2023) for a country that is faced with different economic challenges ranging from post COVID-19 pandemic, economic recessions of 2016 and 2020 and the recent subsidy removal.

Therefore, the research was motivated to investigate how electricity power consumption influences economic growth in Nigeria. The paper uses the Threshold Regression estimation technique to estimate the impact or influence from 1990 to 2022. This research is different from the work of previous researchers that have carried out similar studies in the past in several ways. First to the best of the author’s knowledge, only few studies have investigated how electricity power consumption affects economic growth in Nigeria. Secondly, the research applied the Threshold Regression Analysis Technique that allows for regime switch and an endogenously determined threshold value of low and high electricity power consumption regimes. Thirdly, From the perspective of existing literature on electricity consumption-growth nexus, controversial results can be found. One of the possible reasons is that most of them employed the linear model. Considering the long period of the study, the economic and consumption behaviors may exhibit a nonlinear relationship; thus, a linear model may not be suitable to estimate the actual impact. In addition, decomposing the impacts of electricity power consumption on growth should be explored. Due to the nonlinear causal effect, limited studies have been done on this subject for Nigeria; this study aims to investigate the nonlinear causal effect of electricity power consumption on economic growth in Nigeria using the threshold regression technique.

It is, therefore, imperative to study the nonlinear impact of electricity power consumption on economic growth in Nigeria. Thus, the following are the specific objectives of the study:

i. Examine the nonlinear relationship between electricity power consumption and economic growth in Nigeria

ii. Investigate the impact of electricity power consumption on economic growth in Nigeria

LITERATURE REVIEW

Conceptually, electricity power consumption is the demand for and supply of electricity power level. Electricity power consumption measures the production of power plants and combined heat and power plants less transmission, distribution and transformation losses and own use by heat and power plants (OECD, IEA 2014). Gross capital formation: This is a component of the domestic product expenditure that shows value's economy rather than consumed. The World Bank (2016) defined gross capital formation or gross domestic investment, which consists of outlays in addition to the fixed assets of the economy plus net changes in the level of inventories.

Empirical review

Hünkar, et al (2022) examine the impact of the COVID-19 pandemic on the electricity consumption and economic growth nexus in 30 European countries using quarterly data between 2015Q1 and 2021Q3. The study employed the panel unit root, panel causality, and dynamic panel estimation tests, and the result shows that there is a bi-directional causality between electricity consumption and economic growth during the study period. This means that increased electricity consumption during the COVID-19 pandemic decreases economic growth.

Kouton and Amonle (2019) investigated the impact of renewable energy consumption on inclusive growth in 44 African countries. A generalized Method of Moments (GMM) was employed to estimate the dynamic panel data from 1991 to 2015. The study's main finding revealed that renewable energy consumption has a significant positive impact on inclusive growth in Africa, particularly in African countries experiencing low levels of inclusive growth.

In addition, Yakubu et al. (2020) investigated the impact of electricity power on economic growth in Nigeria between 1981 and 2019 using the Autoregressive Distributed Lag (ARDL) bounds cointegration test. Results revealed that electricity power has a significant impact on economic growth in both the long run and the short run. Sarkodie and Adams (2020) described the importance of electrical energy in production activities to reduce transaction costs, encourage increased output, promote income distribution, and encourage electricity use for people experiencing poverty. Ateba et al. (2018) explained that advanced economic development is characterized by adequate energy, technology, and infrastructure consumption.

Using the Johansen Cointegration test and the Granger Causality test, Pandey and Rastogi (2019) examined the interrelationship of electricity consumption and economic growth to environmental degradation in India and found the short-run causality of electricity consumption, economic growth, and CO_2 emissions. In addition, Njindan (2019) examined the link between electricity power consumption and economic growth in Nigeria by employing VECM and using data from 1971 to 2012. The results show a distinct causal flow from electricity power consumption to economic growth in the short and long run.

In a recent study, Marinaş (2018) examined renewable energy consumption and economic growth. The paper tested the correlation between economic growth and renewable energy consumption for ten (10) European Union (EU) member states from 1990 to 2014, using the Auto-regressive and Distributed Lag (ARDL) modeling procedure. The short-run perspective revealed the transition towards a new energy paradigm, while the long-run approach corresponds to the long-term equilibrium of the analyzed factors. The results show that, in the short run, the Gross Domestic Product (GDP) and Renewable Energy Consumption (REC) dynamics are independent in Romania and Bulgaria, while in Hungary, Lithuania and Slovenia, increasing renewable energy consumption improves economic growth. In another study, Ito (2017) empirically estimated the link between CO_2 emissions, renewable energy and non-renewable energy and economic growth, concluding that the heightened renewable energy consumption had positively influenced economic growth, while conventional energy had no positive impact on real GDP, especially in developed countries. While Afonso, Marques, and

In another study, Dogan (2014) assesses the relationship between energy consumption and economic growth in Kenya, Congo, Benin and Zimbabwe from 1971 to 2011. It finds no causal relationship in Congo, Benin and Zimbabwe, while in Kenya, energy consumption changes led to economic growth. At the same time, Nonejad and Fathi (2014) surveyed the relationship between energy consumption and economic growth in Iran from 1971

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to 2009. The study finds that changes in energy consumption affect economic growth and changes in economic growth impact energy demand. At the same time, Shahaheet (2014) examines the relationship between energy consumption and economic growth in 17 Arab countries from 1980 to 2011. The study finds no link between the two in 16 of the 17 countries except for Kuwait, where changes in energy consumption led to changes in GDP growth. Nonejad & Fathi (2014) and Shahaheet (2014) are studies done in another country with an apparent methodology.

A similar study by Saibu and Jaiyesola (2013) on the energy consumption carbon emission and economic growth in Nigeria: implication for energy policy and climate protection in Nigeria. The study adopted a dynamic methodology of the form of Granger causality and dynamic regression model, which came up with the conclusion that there is a causal relationship between oil production, carbon emission from gas flaring and economic growth in Nigeria; more importantly, carbon emission contributed an impediment to sustainable economic growth in Nigeria. Also, Dlamini (2013) examine the relationship in South Africa from 1971 to 2009. The analysis finds that from 2002 to 2003 and from 2005 to 2006, a change in electricity consumption led to a change in GDP. In other periods, electricity consumption and GDP are not linked. The paper presumes that the two exceptional periods correspond to periods of particular economic significance within the country's electricity market where increases in electricity tariffs occurred. The paper states that in the two periods, growth in electricity consumption led to growth in GDP, but the observed effect was negative due to increases in electricity prices.

While Adebola (2011) investigates the relationship between electricity consumption and real GDP in Botswana from 1980 to 2008, the paper tests a model where economic growth is a function of capital, labor and electricity. The paper finds that long-term increases in energy consumption are associated with increases in real GDP. It also finds that capital formation has an impact on real GDP. The paper speculates that as the economy of Botswana is highly dependent on energy, the ability of capital to influence economic growth positively is partly determined by the availability of adequate energy within the country. At the same time, a study in Ghana by Adom (2011) assessed the link between electricity consumption and economic growth in Ghana between 1971 and 2008. The study states that Ghana's most productive sectors, agriculture and services, are not energy-intensive, and the industrial sector, which theoretically links electrical consumption to economic growth, has declined. As a result, electricity consumption has not been a driver of economic growth. Instead, economic growth has led to greater electricity consumption.

However, Eggoh et al (2011) provided empirical evidence on the relationship between energy consumption and economic growth in 21 African countries between 1970 and 2006. The study finds that a change in energy consumption impacts economic growth, and equally, a change in economic growth impacts energy consumption. In a similar study, Apergis and Payne (2011) use the Granger causality method to examine the relationship between GDP and electric power consumption among 88 countries grouped in high-income, upper-middle-income, lower-middle-income and low-income panels. The study uses a multivariate production function with the dependent variable of real GDP and independent variables of actual gross fixed capital formation, total labor force, and electric power consumption. Causality is bidirectional in high, upper-middle, and lower-middle-income countries but unidirectional from electricity consumption to GDP in low-income countries. The results support the electricity-growth hypothesis for low-income countries. The authors conclude that the causal relationship between electricity consumption and economic growth may depend on the country's stage of development.

Shahbaz and Lean (2012) examine the relationship between electricity consumption and economic growth in both short-term and long-run periods in Pakistan between 1972 and 1999. After the unit root and ARDL bounds test for cointegration, the coefficients in the model are estimated using an unrestricted error correction model (UECM). The results indicate a significant long-run effect of electricity consumption on economic growth.

In another study, Pressely (2012), in the causal relationship between energy consumption and economic growth in Liberia, engaged parametric and non-parametric Granger causality approach, and the study found evidence of distinct bidirectional Granger causality between energy consumption and economic growth.

In the literature on electricity consumption-growth nexus reviewed, controversial results were found. One of the possible reasons is that most of them employed the linear model. Considering the nature of Nigeria’s economy,

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the economic and consumption behaviors may exhibit a nonlinear relationship; thus, a linear model may not be suitable to estimate the actual relationship. In addition, decomposing the impacts of energy consumption on growth should be explored. Limited studies have been conducted on this subject in Nigeria.

METHODOLOGY

Theoretically, one of the models considered for examining growth is the production function, precisely, the Cobb-Douglas, which is given by:

$$X = AK^{\alpha} \mathcal{L}^{(1-\alpha)} \quad (1)$$

$X, K, L,$ and A represent output, capital, labor, and total factor productivity, respectively. Eq. (1) can be expressed in intensive form:

$$x = AK^{\alpha} \quad (2)$$

where x = X / L, is gross output per worker; and k = K / L, capital per worker. Finally, as is well-known, $0 \prec \alpha \prec 1$, which implies that there are diminishing returns to output per worker.

The (net) output is defined by

$$y = x(1 - \lambda) \quad (3)$$

Y = net output, y = Y / L, net output per worker, and λ = a fixed proportion of the domestic (gross) output devoted to emission control.

The capital accumulation equation is given by:

$$dk/dt = sAK^{\alpha}(1 - \lambda) - (\delta + n) \quad (4)$$

Where dk/dt = change in capital per worker. It is assumed that a proportion of net output is saved and invested. The first term on the right-hand side, $sAK^{\alpha}(1 - \lambda)$, represents gross investment; the second term, $\delta + n$, is the sum of the depreciation rate and the labor force growth rate.

Eq. (4) can be rewritten as follows:

$$dk/dt = sAK^{\alpha}(1 - \lambda) - (\delta + n)k \quad (5)$$

The model in this paper is specified based on the above theoretical underpinning.

Nature and Sources of Data

The study spans 1990 to 2022 and uses time series data for Nigeria. The relationship between electricity consumption and economic growth is empirically examined. The data on electricity consumption (measured as electricity power consumption, kWh per capital), investment (measured as Gross Fixed Capital Formation % of GDP), Economic Growth (GDP, constant 2015 US$) and labor (labor force, total) are sourced from World Development Indicators (WDIs) of the World Bank[1]. All the variables were used based on the Cobb-Douglas production function highlighted earlier. The availability of data justifies the use of the periods.

METHOD OF DATA ANALYSIS

The empirical analysis starts with applying the stationarity test among the variables of interest to determine the properties of the series for a better choice of methodology. After that, the paper assesses the two variables of interest (electricity power consumption and economic growth) to see if they exhibit non-linearity to apply a

[1] https://databank.worldbank.org/source/world-development-indicators

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nonlinear model to avoid spurious regression. The paper was motivated to do that because of the irregular behavior observed after plotting the two series on a graph. Given the presence of non-linearity in the data, the threshold regression was used to examine the relationship.

This study is built on the framework of a two-regime structural equation. In its typical state, the threshold regression follows a two-state autoregressive model, with a lag in both regimes. In this model, the time path of a series y_t is as follows:

$$y_t = \begin{cases} a_{10} + a_{11}y_{t-1} + e_{1t} \; if \; y_{t-1} > \tau \\ a_{20} + a_{21}y_{t-1} + e_{2t} \; if \; y_{t-1} \leq \tau \end{cases} \quad (6)$$

Where τ denotes the threshold value y_t is the dependent variable; a_{10} and a_{20} are the constants in both regimes, respectively, while e_{1t} and e_{2t} are error terms for the two regimes, respectively, the time path of y_t progresses by how its previous values change across the threshold value. If $\tau = 0$, the variance of the error terms would not be equal (i.e., $var(e_{1t}) \neq var(e_{2t})$), and provided that y_t is a stationary series, the future values of y_t are dependent on a_{10} when $y_t > 0$, and a_{20} when $y_t \leq 0$, as well as a shock to e_{1t}, making the y_t to switch across regimes. For instance, if an initial value for y_{t-1}>0, it is expected that y_t, being run by the equation $y_t = a_{10} + a_{11}y_{t-1} + e_{1t}$, and in regime 1, would decline in the direction of $\frac{a_{10}}{1-a_{11}}$ in the long-run at the rate of a_{11}. Since y_t is a stationary series, its value converges in the long run to $\frac{a_{10}}{1-a_{11}}$ in regime 1 and $\frac{a_{20}}{1-a_{21}}$ 2. However, depending on its value, e_{1t}can cause y_{t-1} to increase or decrease, passing the threshold value of $\tau = 0$ to a value equal to, or lower than 0 and switching y_t to regime two, where the value of y_t would be dependent on equation $y_t = a_{20} + a_{21}y_{t-1} + e_{2t}$, and move in the direction of $\frac{a_{20}}{1-a_{21}}$, in the long-run, at the rate of a_{21}. This model is called a self-exciting threshold autoregressive (TAR) model, as the state-dependent variable is also the state-determining variable.

If the variance of the error terms in both regimes is equal, i.e., $var(e_{1t}) = var(e_{2t})$, the two-state TAR model can be rewritten as:

$$y_t = a_0 + a_1 I_t y_{t-1} + a_2(1 - I_t)y_{t-1} + e_t \quad (7)$$

I_t is a dummy variable in this equation, such that $I_t = 1 \; if \; y_{t-1} > \tau = 0$ and $I_t = 0 \; if \; y_{t-1} \leq \tau = 0$. Consequently, y_t is directed by $a_0 + a_1 I_t y_{t-1} + e_t$ whenever $y_{t-1} > 0$, and $a_0 + a_2(1 - I_t)I_t y_{t-1} + e_t$, whenever $y_{t-1} \leq 0$.

The estimation method for the two variants of the TAR model is the simple ordinary least squares (OLS) regression method. This is possible after constructing two new variables, $I_t y_{t-1}$ and $(1 - I_t)y_{t-1}$, to replace y_{t-1} in states 1 and 2, respectively.

The two-state TAR models presented are simple forms of more general TAR models. Generally, Equations 6 and 7, with p lags, can be rewritten as Equations 8 and 9, respectively.

$$y_t = \begin{cases} a_{10} + \sum_{i=1}^{p} a_{1i} y_{t-i} + \sum_{i=1}^{p} b_{1i} x_t + \partial_{1i} \emptyset_t + e_{1t} \; if \; z_{t-d} > \tau \\ a_{20} + \sum_{i=1}^{p} a_{2i} y_{t-i} + \sum_{i=1}^{p} b_{2i} x_t + \partial_{1i} \emptyset_t + e_{2t} \; if \; z_{t-d} \leq \tau \end{cases} \quad (8)$$

$$y_t = a_0 + \sum_{i=1}^{p} a_{1i} y_{t-i} + \sum_{i=1}^{p} \partial_{1i} \emptyset_t + \sum_{i=1}^{p} b_{1i} I_t x_{t-i} + \sum_{i=1}^{p} b_{2i}(1 - I_t) x_{t-i} + e_t \quad (9)$$

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VIII Issue VIII August 2024

Where $I_t = 1\ if\ z_{t-d} > \tau$ and $I_t = 0\ if\ z_{t-d} \leq \tau$.

Except for $\partial\ and\ \emptyset,\ d, z, x$ and parameter b, a vector of non-regime dependent regressors with ∂as the corresponding vector of coefficients, the variables and parameters are as defined in Equations 8 and 9. The threshold variable is z_t, which can be $y_t,\ x_t$ or even a variable not included in the model.

The threshold value can be predicted within the system, premised on the researcher's assumptions. According to Chan (1993), multiple variants of equation 9 with potentially different threshold levels should be estimated to evaluate the threshold within the system. A visual plot of the Sum of Squared Residual (SSR) will be created. The existence of multiple thresholds in these SSRs would mean that a distinct local minimum (trough) holds. The threshold value(s) is/are the threshold number(s) that coincide with the minimum point(s) of the trough(s) in the SSR function graph (s). This condition is essential but needs to be improved. The existence of a threshold relationship is sufficient if b_1 and b_1 in Equation 4 have opposite signs and are statistically significant.

Correspondingly, the optimal lag parameter, which indicates the time frame of the adjustment process (it is the period wherein the regime transition occurs), can be ascertained by estimating the y_t model with distinct values and choosing the model with the lowest Residual Sum of Squares (RSS), or the lowest Akaike Information Criteria (AIC) and Schwarz Info Criteria (SIC). d can be 0, 1, 2 ... The model will be in states 1 if $z_{t-d} > \tau$ and 2 if $z_{t-d} \leq \tau$.

This study employs Chan's technique to a revised version of Equation 9 to determine the electricity consumption threshold(s) beyond which further increases in electricity consumption harm economic growth.

As a result, the estimated model for the study is as follows:

$$y_t = a_0 + \sum_{i=1}^{p} a_{1i}(1 - I_t)x_{t-i} + \sum_{i=1}^{p} a_{2i}I_t x_{t-i} \sum_{i=1}^{p} b_{1i}\emptyset_{t-i} + e_t \qquad (10)$$

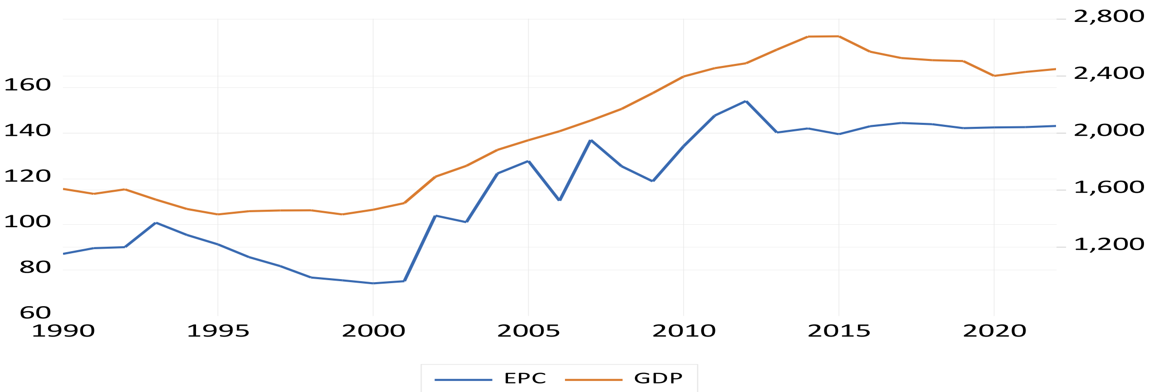
Where y_t and x_t represent economic growth and electricity consumption, respectively, t is the vector of control variables, which, in this study, includes investment and labor.

EMPIRICAL RESULTS AND DISCUSSIONS

This section starts with some pre-estimation tests.

Stylize facts.

Figure 1: Trends of Electricity Power Consumption and Economic Growth



Source: Author’s Compilation eviews 12 results

Figure 1 shows electricity consumption and economic growth moving in the same direction. This indicates a proper relationship between the two may exist after empirical examination. However, an irregular movement

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could be seen in the trends. This suggests that regime changes characterize the series. The paper, therefore, further subjects the series to non-linearity checks to examine the appropriate methodology.

Table 1: Descriptive Statistics

	EPC	**GDP**	**GFC**	**LF**
Mean	116.0770	2015.626	28.37228	49489907
Median	122.3339	2013.274	26.74420	48846711
Maximum	154.1723	2679.555	53.12219	73272344
Minimum	74.14614	1429.012	14.16873	31936585
Std. Dev.	26.87171	463.4575	11.23507	11773501
Skewness	-0.233270	0.004011	0.382192	0.324295
Kurtosis	1.481000	1.341286	2.087208	2.113925
Jarque-Bera	3.471903	3.783168	1.949024	1.657971
Probability	0.176232	0.150833	0.377377	0.436492
Observations	33	33	33	33
Note: EPC means electricity power consumption, GDP is gross domestic product, GFC is gross fixed capital formation, and L.F. denotes labor force.				

Source: Author’s Compilation eviews 12 results

From Table 1, the skewness values for all four series are very close to 0, indicating that they are approximately symmetric. The kurtosis values for all four series are slightly higher than 3, indicating that the tails are slightly heavier than those of a normal distribution. The Jarque-Bera statistics are not extremely high, and the associated p-values are not significant, suggesting that the series exhibits some normality in distribution.

Table 2: Correlation Analysis

Varaibles	EPC	GDP	GFC	LF
EPC	1.000000			
GDP	0.948708	1.000000		
	0.0000	-----		
GFC	-0.781518	-0.814589	1.000000	
	0.0000	0.0000	-----	
LF	0.847119	0.875130	-0.673782	1.000000
	0.0000	0.0000	0.0000	-----

Source: Author’s Compilation eviews 12 results

The paper conducts correlation analysis to examine the independent variable with high correlation (above 0.80) to know how to handle them to avoid multicollinearity issues. From Table 2, the two independent variables with coefficients above 0.80 are L.F. and EPC. The paper, therefore, transformed all the series by taking the growth rate of all the series following the work of Aydin, Akinci and Yilmaz (2016) before the empirical analysis to circumvent the issue of multicollinearity and stationarity concerns.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VIII Issue VIII August 2024

Table 3: Stationarity Test

	ADF Test				
	EPCG	**GDPG**	**GFCG**	**LPG**	**Conclusion**
Level	-6.5398***	-3.6833***	-3.2652***	-4.1116***	stationary
First Difference	-8.0328***	-9.3382***	-3.3059***	-6.2149***	stationary
	Minimize Dickey-Fuller t-statistics Break Test				
Level	-8.5470	-5.0510	-4.7900	-6.3982***	stationary
Break Date	2002***	2002***	2016**	2013***	
Notes: ***, **, and * represent 1%, 5% and 10% statistical significance, respectively.					

Source: Author's Compilation eviews 12 results

The paper, therefore, tests the stationarity of the transformed series (growth rates of the series) before the proper estimations. From Table 3, both the ADF and Minimize Dickey-Fuller t-statistics break tests indicate that the series is stationary at level. The break dates of the two variables of interest (economic growth and electricity power growth) are found to be significant. These results further indicate that the series are characterized by non-linearity in their process.

Recall that the paper observes some irregular movement of the two variables of interest (EPC and GDP), and the stationarity test indicates a regime shift in the series. That motivates the paper to conduct Brock, Dechert, and Scheinkman (BDS) test for non-linearity to examine if the series is characterized by regime shift.

Table 4: BDS Test for EPCG

Dimension	BDS Statistic	Std. Error	z-Statistic	Prob.
2	0.139174	0.008116	17.14899	0.0000
3	0.237073	0.013012	18.21961	0.0000
4	0.295364	0.015631	18.89615	0.0000
5	0.327778	0.016440	19.93817	0.0000
6	0.335110	0.016005	20.93819	0.0000

Source: Author's Compilation eviews 12 results

Table 5: BDS Test for GDPG

Dimension	BDS Statistic	Std. Error	z-Statistic	Prob.
2	0.175452	0.008029	21.85359	0.0000
3	0.297429	0.013005	22.87012	0.0000
4	0.380853	0.015783	24.12987	0.0000

5	0.426601	0.016771	25.43701	0.0000
6	0.452262	0.016495	27.41829	0.0000

Source: Author's Compilation eviews 12 results

Tables 4 and 5 provide results from the BDS (Brock et al.) test for non-linearity for EPCG and GDPG. The BDS test is used to detect the presence of non-linearity in a time series. The test is conducted at various dimensions (the number of lags) to assess the non-linearity in the data. The BDS test for EPCG is conducted at dimensions 2 through 6. For all dimensions, the BDS Statistic is significantly different from zero, with extremely low p-values. This indicates strong evidence of non-linearity in the EPCG series for all tested lags.

Like the EPCG series, for all dimensions of GDPG, the BDS Statistic is significantly different from zero, with extremely low p-values. This indicates strong evidence of non-linearity in the GDPG series for all tested lags. In both cases, the BDS test results suggest that the time series data for both EPCG and GDPG exhibit nonlinear behavior. The low p-values indicate statistically solid evidence to reject the null hypothesis that the data is linear and supports the presence of non-linearity in the series, regardless of the dimension (number of lags) considered in the test.

Threshold Analysis

All the pre-estimations conducted earlier favored a regime change model for the analysis. The paper, therefore, employed a threshold regression analysis for its estimation.

Table 6 Threshold Autoregressive Analysis

Threshold variable: EPCG Dependent Variable: GDPG				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EPCG < 0.1301 -- 28 obs				
EPCG	-0.238173	0.094190	-2.528632	0.0176
0.1301 <= EPCG -- 4 obs				
EPCG	0.255638	0.056487	4.525578	0.0001
Non-Threshold Variables				
GFCG	-0.002560	0.023103	-0.110793	0.9126
LFG	0.267065	0.213071	1.253405	0.0208
GDPG (-1)	0.468782	0.109749	4.271384	0.0002
R-squared	0.559701	Mean dependent var		4.053702
Adjusted R-squared	0.494471	S.D. dependent var		3.782560
S.E. of regression	2.689421	Akaike info criterion		4.959130
Sum squared resid	195.2906	Schwarz criterion		5.188151
Log-likelihood	-74.34608	Hannan-Quinn criteria.		5.035044
Durbin-Watson stat	1.800094			

Source: Author's Compilation eviews 12 results

Table 6 is the result of a threshold autoregressive model. The objective is to understand the relationship between

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economic growth (GDPG) and electricity power consumption growth (EPCG), investment growth (GFCG), labor force growth (LFG), and lagged GDP growth (GDPG (-1)). The threshold variable in this case is EPCG, and the model is divided into two regimes based on the endogenously determined threshold value of EPCG, which is 0.1301.

In the regime where EPCG is less than 0.1301 (low electricity power consumption growth), there is a negative relationship with economic growth (GDPG). A one-unit decrease in EPCG is associated with a decrease of 0.2381 units in GDPG. The p-value suggests that this relationship is statistically significant at the 0.05 level.

In the regime where EPCG is greater than or equal to 0.1301 (higher electricity power consumption growth), there is a positive relationship with economic growth (GDPG). A one-unit increase in EPCG is associated with an increase of approximately 0.2556 units in GDPG. The p-value suggests that this relationship is statistically significant at the 0.05 level. The two results align with Phadkantha and Yamaka (2022), who also found a nonlinear relationship between economic growth and electricity consumption in Thailand.

Investment growth (GFCG), which is one of the control valuables, does not have a statistically significant impact on economic growth (GDPG). The p-value is high, indicating that changes in investment growth are not strongly related to changes in GDPG in this model. This does not align with the Cobb Douglass production function underpinning this study. This is probably because Nigeria's power sector has yet to be genuinely privatized. Therefore, the sector needs to attract meaningful investment.

Labor force growth (LFG) has a statistically significant positive impact on economic growth (GDPG). A one-unit increase in LFG is associated with an increase of 0.2671 in GDPG. The p-value suggests that this relationship is statistically significant at the 0.05 level. The results are in line with the theory. This could be due to the abundant labor force available in Nigeria.

Lagged GDP growth (GDPG (-1)) has a statistically significant positive impact on current economic growth (GDPG). This suggests that the economy's past performance is positively related to current economic growth. A one-unit increase in GDPG (-1) is associated with an increase of approximately 0.4688 units in GDPG.

Overall, the threshold regression model suggests that the impact of electricity power consumption growth (EPCG) on economic growth (GDPG) differs depending on whether EPCG is below or above the threshold value. There is a negative relationship in the low EPCG regime, while in the high EPCG regime, there is a positive relationship with GDPG. Factors like labor force growth and lagged GDP growth also influence economic growth in this model. This also indicates that economic growth and electricity power consumption are nonlinear.

The R-squared at 0.559701 is okay, as the independent variables in the model are said to explain about 56 percent of the variations in the dependent variable.

Diagnostics

Table 7 Diagnostic tests

	Null hypothesis	Test statistics
Breusch-Godfrey serial correlation LM test	No autocorrelation	$\chi^2_{(1)}$ = 0.2296[0.7964]
Ramsey's RESET test	The model is correctly specified	$\chi^2_{(1)}$ = 0.3994[0.6928]
Jarque-Bera normality test	Normality of error term	$\chi^2_{(2)}$ =1.4999[0.4723]
ARCH test	Homoskedasticity	$\chi^2_{(1)}$ = 1.3154[0.2923]

Source: Author's Compilation eviews 12 results

Post-estimation tests were conducted to validate the model. The null hypothesis of diagnostic tests of no serial correlation, normality of distribution of residuals, no functional form misspecification and homoscedasticity could not be rejected, as shown in Table 7. The results are evidence of the adequacy of the threshold autoregressive model.

CONCLUSION AND RECOMMENDATIONS

This paper provides valuable insights into the relationship between economic growth (GDPG) and various economic indicators, focusing on electricity power consumption growth (EPCG). The threshold variable, EPCG, has been identified as a critical determinant, dividing the model into two regimes based on an endogenously determined threshold value of 0.1301.

The regime with EPCG values below 0.1301, characterized by low electricity power consumption growth, has a negative relationship with economic growth (GDPG). Specifically, a one-unit decrease in EPCG is associated with a decrease of 0.2381 units in GDPG, and this relationship is statistically significant at the 0.05 level. Conversely, there is a positive relationship with economic growth in the regime with EPCG values greater than or equal to 0.1301, characterized by higher electricity power consumption growth. A one-unit increase in EPCG is associated with an increase of approximately 0.2556 units in GDPG, and this relationship is also statistically significant at the 0.05 level. These findings support a nonlinear relationship between economic growth and electricity consumption, which aligns with prior research by Phadkantha and Yamaka (2022) in Thailand.

The findings from this study provide insights that can inform policy and investment decisions in Nigeria. Based on the results, it is evident that electricity power consumption growth plays a critical role in shaping economic growth. Therefore, the government and relevant stakeholders should consider policies and initiatives that encourage the expansion and modernization of the power sector to facilitate higher electricity consumption. This could involve investing in infrastructure, promoting energy efficiency, and attracting private sector investment.

Furthermore, given the positive influence of labor force growth on economic growth, there is an opportunity to harness the country's abundant labor force. Policymakers could focus on policies that enhance workforce development, education, and training to ensure the labor force is skilled and productive, thus contributing to economic growth.

The non-significant impact of investment growth on economic growth calls for reevaluating the privatization efforts in the power sector. Efforts to attract meaningful investments and create an environment conducive to private sector participation should be a priority.

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