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AN AUTOREGRESSIVE DISTRIBUTED LAGGED (ARDL) BOUND TESTING APPROACH TO ELECTRICITY SUPPLY AND ELECTRICITY TARIFF IN NIGERIA

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Abstract

The paper empirically employed the Autoregressive Distributed Lagged (ARDL) Bound Test Approach to evaluate data acquired from the CBN Statistical Bulletin, NBS, MYTO-2015 Distribution Tariffs, NERC, PHCN, NEPA, and WB/WDI Database from 1971 to 2021. The ARDL result estimate indicates that in the short and long run electricity supplies is consequential but no influence on electricity tariff and gross domestic product. This indicates that when electricity supplies grow, so does electricity tariff and gross domestic product; however, the gain is not statistically significant. Long-run and short–run electricity supply has not favor and no influence on per capita income. This suggests that as electricity supply increase, per capita income declines. The ECM coefficient, which represents the disequilibrium, is adjusted and brought back to equilibrium at a rate of 22.9% the next year. The R2 of around (77.9%) percent and the adj-R2 of about (74.4%) percent indicated that the model fit well since these levels of total variations in power supply were explained by changes in the explanatory variables. We concluded that it is essential for the development of the Nigerian electricity supply business to have a tariff that would balance the interaction between electricity supply and electricity tariffs while also ensuring a margin of returns on investment. This study recommends that Federal Government of Nigeria should spend extensively in the transmission subsector of the Nigerian Electricity Supply Industry (NESI) to increase its efficiency. In addition, private sector investment in electricity should be encouraged, as industry predictions for the next decade show a favorable trend, coupled with continuous macroeconomic progress.

Keywords: *Electricity Supply, Tariff, Gross Domestic Products, Per Capital Income, Economic Growth.*

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1. Introduction

Over the years, the Nigerian electricity industry has been rife with ominous stories about its repeated inability to satisfy its commitments to Nigerians. The problems can be traced back to the period between 1981 and 1985, during the fourth National Development Plan, when there was an oil boom and power demand exceeded 10%. The rapid growth rate in the economy made it difficult for installed capacity to meet the load requirements of residential, commercial, and industrial consumers (Ikeonu, 2006). In contemporary times, there has been an inability to offer adequate and effective electrical infrastructure within the framework of governance in Nigeria. This challenge emanates from insufficiencies in transmission capacity, an unsatisfactory corporate governance history, and a pricing system that fails to support the economics underlying power generation, transmission, and end-user distribution (NAPE, 2016). This cluster of concerns has emerged as a major impediment to the reliable and effective delivery of electrical power in Nigeria. As a result of such challenges, the power sector in Nigeria has persistently grappled with the provision of efficient electricity services to both residential and industrial users. At present, Nigeria is experiencing a concerning trend of decline, which presents the possibility of an insufficient grid-based electricity supply in the upcoming five decades. In an effort to arrest a trajectory of decline, the government undertook a process of reinvigorating the electricity sector by enacting the Electric Power Sector Reform Act (EPSRA) of 2005, which created the Nigeria Electricity Regulatory Commission. The ultimate aim of this initiative was to expand electricity-generating capacity throughout the country. Notwithstanding the government's concerted efforts to enhance the power sub-sector infrastructure and thereby mitigate the demand-supply disparity in the nation, the provision of energy continues to be unpredictable. The delivery of electricity in developing nations, specifically Nigeria, incurs relatively higher costs in comparison to those in developed nations. Thus, the sustained implementation of non-cost-based electricity tariffs, which persistently impede investment, is likely to exert an adverse impact on the facets of electricity generation, transmission, and distribution. "Alternative energy sources have been suggested by some experts as a viable remedy for the electricity supply shortfall experienced in Nigeria." According to Beck and Cull (2014), the availability of alternative energy sources for emerging countries is notably limited and presents a considerable financial burden. Therefore, the inadequacies in the provision of electricity in Nigeria can be ascribed to two key factors. The primary aspect concerns the electricity tariff, which is subjected to considerable subsidization from the government. Concurrently, the second factor pertains to the dearth of restructuring strategies that are inclined towards market forces. Boniface (2014) examined the Negative impact of high electricity tariff on consumers/end-users in some developing Countries especially Nigeria. The research indicated that Nigeria's constant epileptic power supply is the consequence of long-standing corruption, the availability of faulty and inadequate components such as transformers, poor management, neglect of critical concerns, and a cheap energy pricing. During the 12th annual power and utilities roundtable hosted by PwC Nigeria at the hybrid event, Ahmad Zakari (2022) stated that the panacea to achieving an adequate supply of electricity is to adopt cost-reflective electricity tariffs, which will boost the country's electricity supply in the long run because the provision of enough and steady power to customers is the backbone of every nation's socioeconomic growth.

Electricity tariffs has a critical role in moderating electricity access it is therefore, for imperative for the power sector to design an electricity pricing template that will not create a large deadweight. According to the 2020 Doing Business report, one of the greatest barriers for the private sector is obtaining access to power. The Nigerian electricity business, like any other economic sector, has its own set of challenges that has negatively contributed to the country's progress in eradicating poverty, rising unemployment, and falling living standards. It is estimated that 47% of Nigerians do not have access to grid energy, and those who do experience frequent power outages. Furthermore, the economic impact of power outages in Nigeria is projected to be about $28 billion, or 2% of the country's GDP. As a result, increasing power sector performance, particularly in non-oil sectors such as manufacturing and services, will be critical to unlocking economic development (World Bank, 2020). Ado and Josiah (2015) investigated the influence of insufficient electricity supply on the operations of small-scale enterprises in Nigeria's northeast. The study demonstrates the severity of power outages as well as the expenses imposed by power outages on the operation of this type of business in the region. They stated that policy emphasis should be placed on rejuvenating Nigeria's electrical industry because access to power in Nigeria remains restricted, with millions of people remaining without this crucial service.

Hence, the implementation of the country's commercialization program of the power sector remains imperative in achieving sustained delivering of quality service and increasing access to electricity to the growing demand for national grid supplies. Nigeria being the largest economy has the highest number amongst the countries in Sub-Sahara Africa (96 million) without access to power (International Energy Agency, 2015). Thus, increasing access is critical for poverty reduction in Nigeria and it can boost corporate productivity and production, generate jobs, and relieve individuals of the burden of self-generation (which is generally more expensive). Greater access can generate a positive feedback loop by raising earnings and allowing the poorest to invest in education and other productive resources that are critical to long-term development.

Consequently, given the persistent demand for an increase in electricity tariffs that pervades the economic and political landscape of Nigeria, coupled with the dearth of comprehensive research examining the causal nexus between electricity supply and electricity tariffs in the country. Nguyen (2012) conducted an investigation into the ramifications of escalated electricity tariffs on the overall economy of a nation. The results of the research demonstrate that the augmentation of electricity tariffs has the potential to affect the costs of end-user merchandise and services and may result in a disproportionate impact on household income quintiles, as evaluated through a static input-output methodology. The investigation determined that such a surge would result in an escalation of the cost of all other commodities. The magnitude of the price impact is relatively insignificant. The present investigation holds great significance in ascertaining the impact of electricity tariff rates on both the electricity supply market and per capita income in Nigeria. Several perspectives suggest that an increase in electricity costs during periods of low per capita income may lead to a reduction in overall quality of life, an increase in unemployment rates, and heightened feelings of insecurity within the community. Sambo (1987) conducted a study that establishes a positive correlation between a Nigeria's per capita consumption of electricity and a higher standard of living. Consequently, the pricing of electricity has significant implications on the socio-economic conditions of low-income laborers and rural communities. Specifically, it can lead to a substantial increase in living expenses. The findings suggest that a consistent and proficient supply of electricity is essential for the progress of any economy. Numerous contemporary operations are rendered inoperative when there is a discontinuation or variation in the energy supply.

2. Literature Review

Conceptual Review

Economic growth, Electricity tariffs and Per Capita Income

The fundamental interdependence of consumption and supply renders the role of electricity supply in driving economic growth highly consequential. Ogundipe and Apata

(2013) employed a vector error correction model (VECM) to analyze the causal relationship between energy consumption and economic growth in Nigeria. A distinct co-integrating relationship was discovered among variables in the study, revealing that energy consumption impacts economic growth in both the short and long term. Since the pioneering work of Kraft and Kraft (1978), investigations on the relationship between energy consumption and economic development have been significant in the energy literature, as well as in Nwosa and Akinbobola (2012). Subsequent research on the aggregate energy consumption and economic growth nexus have been done in both industrialized and developing nations, but their conclusions have been conflicting. Despite the copious amount of extant literature, a paucity of discrete investigations has been undertaken to explore the impact that the power supply exerts on the economic progress of Nigeria. Throughout the years, the Nigerian power sector has predominantly been driven by public efforts, with the implementation of electricity tariffs that heavily subsidize energy accessibility and alleviate the electricity supply and demand disparity, which continues to impede the economic growth of the nation. In order to attain energy efficiency, a reform in the power industry in the country was instigated as a response to the widening discrepancy between electricity demand and supply. The primary objective is to augment the quantity of electricity accessible to meet the overall demand. Due to the significance of power consumption as a determinant of business performance, the country adopted a liberalized reform model that is cost-based aimed at making the energy sector private-driven with the goal of attaining optimal energy efficiency. This reform is consistent with the United Nations Sustainable Development Goals 7, 9, 11, and 12 (United Nations, 2015; Asaleye et al., 2020). Thus, efficient electricity supply has significant ramifications for company performance since a shortage of power supply will lead to an overreliance on alternate energy sources, which can be more expensive, such as solar, coal, and generators. When a company relies heavily on alternative energy sources, its profit suffers. In addition, the firm's ability to reach the same level of output will have an impact on the rate of employment. (Enang, 2011) revealed a comparable relevance of power supply on growth. In a similar research, Ekpo, Chuku, and Effiong (2011) discovered that utilizing ARDL bound testing on real GDP per capita, population, power consumption, and industrial production from 1970 to 2008, all factors were significant in impacting GDP per capita.

Theoretical Review

The study adopted two theories to established the causal relationship between electricity supply and electricity tariffs in Nigeria and thus, the theories are: the theory of optimal electricity tariffs and Ramsey Price model.

The Theory of the Optimal Electricity Tariff

The theory of the optimal electricity tariff was created by economists Kahn (1970), Botteux (1956) and Steiner (1957). The marginal willingness to pay (WTP) represents the foundational postulate within the present context. "The discernment between off-peak and peak demand is distinguished by unique characteristics." The generation of willingness to pay (WTP) for capacity is contingent upon the discounting of marginal costs associated with electricity production. The horizontal aggregation of the willingness to pay (WTP) is deemed necessary to derive the comprehensive marginal WTP for capacity while acknowledging the public good nature of power generation capacity. This approach prioritizes the summation of consumer valuations across a broad range of capacity levels rather than exclusively focusing on individual valuations for specific capacity increments. It is feasible to determine the optimal electricity generation capacity through the calculation of the investment and capacity expenditures attributable to the construction of power plants designed for both base load and peak load supply. The theory is extended to cover electricity industry models with uncertainty in future conditions and intertemporal linking, such as generation and investment. An optimal pricing structure that takes these into account is imperative. It would induce participants (suppliers and consumers) to make profit-maximizing investment and operation decisions that are socially optimal.

Ramsey Price Model

The Ramsey pricing model, which is identical to the ideal grid price structure, can be used by regulators to allocate capacity costs to the two demand groups in the best possible way. The establishment of efficient competition along the entire electricity value chain is one of the goals of the liberalization of the electricity market. When there is competition, the market chooses the price of equilibrium electricity generation. Simona (2016) evaluate the Ramsey prices in the Italian electricity market using estimation of a complete system of hourly demand in 2010–2011. The research findings revealed that the optimal pricing scheme outperforms both the present uniform price scheme and the plan to charge the existing supply zone rates to the demand side in the Italian energy market for the day ahead. Therefore, regulators should refrain from imposing Ramsey pricing on the generation business and let the markets to operate autonomously. Ramsey pricing holds that the price markup above marginal cost is the inverse of the price elasticity of demand. The present study has implemented the Ramsey price model to investigate the potential impact of utilizing a disaggregated pricing model for the provision of electricity services to suppliers and consumers in Nigeria.

Empirical Review

According to Amusa (2009), they applied a bounds testing approach to co-integration within an autoregressive distributed lagged framework to examine the aggregate demand for electricity in South Africa during the period 1960–2007. According to the findings, income is the primary factor influencing electricity demand over the long term. Therefore, it can be inferred that the aforementioned statement is true. In order to enhance the efficacy of electricity supply and consumption, upcoming pricing plans need to ensure that electricity tariffs are reflective of costs and prioritize the objective of augmenting efficiency. Notably, considering the inconsiderable effect of electricity tariffs on the overall demand for electricity, this remains a pivotal aspect to consider. The results of the study indicate that, over an extended period, income constitutes the primary determinant of total electricity consumption in South Africa. A study on The Impact of Electricity on Economic Development: A Macroeconomic Perspective was conducted by Stern, Burke, and Bruns (2017). 136 nations provided panel data for the study. Cross-sectional regression analysis was used to examine the collected variables. The study found that the countries under study's electricity used had a significant impact on their economic progress. As a result, it was discovered that the countries where studies were conducted needed a consistent supply of electricity for growth and development. Taiwo (2020) evaluate energy tariffs, Income and electricity consumption in Africa: The Role of Technological Innovation. The study revealed that technological innovation has a minimal influence on electricity usage in Africa. Other factors of relevance, however, have varying effects on electricity consumption; for example, although per capita income and population growth have a positive and substantial influence on electricity consumption, energy tariffs and FDI inflows had a negative and significant effect. Therefore, this research findings indicates that electricity tariffs have insignificant influence on energy or electricity consumption. In modern economies, an inexpensive and stable supply of power is a requirement for economic growth and long-term development.

Therefore, despite the plethora of literature available on electricity supply, the correlation linking electricity supply and electricity tariffs in Nigeria has yet to be comprehensively studied, thus creating a deficit in the existing body of research. The persistence of the electricity supply and demand discordance in Nigeria, alongside the issues pertaining to electricity pricing, constitutes significant impediments to the sustainability of the nation's power sector in the long run. Undoubtedly, the undertaking of this research holds significant relevance, as its outcomes are poised to furnish Nigerian policymakers with the necessary insights for determining without to allowed full implementation of cost-reflective electricity tariffs or to continue with the present electricity tariffs that has negative effect on investment to increase electricity supply in Nigeria.

3. Methodology

This study aims to examine the correlation that exists between electricity supply and electricity tariffs in Nigeria. This investigation is based on the country's Gross Domestic Product (GDP), per capita income, as well as electricity supply and prices. This study employed secondary data, specifically time series data, for the purpose of analysis. An empirical investigation was conducted based on a year-long dataset spanning from 1971 to 2021. The present investigation applies the ARDL methodology, which refers to the autoregressive distributed lag model. The ARDL modeling analytical approach incorporates both stationary and non-stationary variables into the model, as opposed to the ordinary least squares (OLS) method. The observation that a violation of the initial condition, denoted by I(0), leads to the emergence of variable usage without due consideration of the enduring relationship between the regressors and the regression is a well-entrenched notion. This trend is further compounded by the heightened susceptibility to undesirable outcomes, such as erroneous findings and suboptimal estimates.

Specifically, the model is specified in the functional form as follows:

ELECT_SP = f (ELECT_T, GDPG, PER_CAP)- (1)

This can be explicitly written in an econometric form as:

$ELECT_t = \beta_0 + \beta_1 ELECT\_Tt + \beta_2 GDPGt + \beta_3 PER\_CAPt + et$ - - - - - - - - - - - - - - - ---------(2)

In a single-equation framework, ARDL models are frequently used to investigate dynamic relationships using time series data. The dependent variable's current value is permitted to be reliant on both its own historical values (the autoregressive component) and the historical and current values of other explanatory variables (the distributed lag part). The variables might either be stationary, non-stationary, or a combination of the two. The ARDL model may be used to distinguish between long-run and short-run effects, as well as to test for cointegration or, more broadly, for the presence of a long-run connection among the variables of interest. This is done using its equilibrium correction (EC) representation.

An ARDL model can have the following general form:

$y_t = \beta_0 + \beta_1 y_{t-1} + \cdots. + \beta_k y_{t-p} + \alpha_0 x_t + \alpha_1 x_{t-1} + \alpha_2 x_{t-2} + \cdots + \alpha_q x_{t-q} + \varepsilon_t$ - - ------(3)

Where ε_t is a random "disturbance" term.

Which becomes;

$\triangle y_t = \beta_0 + \sum\beta_1 \triangle y_{t-1} + \sum\boldsymbol{\gamma}\triangle X1t\text{-}j + \sum\eth k\triangle 2t\text{-}k + \boldsymbol{\Phi} zt\text{-}1 + \boldsymbol{e}t$ - - - - - - - - - - - - - - - - - -- - -- - (4)

$\triangle ELECT\_SP_t = \beta_0 + \sum\beta i\Delta ELECT\_SPt\text{-}i + \sum\beta_1\Delta ELECT\_Tt\text{-}j + \sum\beta_2\Delta GDPGt\text{-}k + \sum\beta_3\Delta PER\_CAPt\text{-}m + \theta_0 ELECT\_SPt\text{-}_1 + \theta_1 ELECT\_Tt\text{-}_1 + \theta_2 GDPGt\text{-}_1 + \theta 3PER\_CAPt\text{-}_1 + et$ - - - - - - - - - - - - - - - - (5)

Apriori Expectation

The coefficient of the electricity tariff, gross domestic product and per capital income are expected to be positive because an increase and consistency of electricity supply, tariff, GDP and per capital income confirmed as being important determinant of economic growth ceteris paribus that is the slope of the coefficient $\beta_{1,}$ β_2 and β_3.

4. Data Analysis and Discussions

Table 1: ADF Unit Root Test

Variables	Staionarity at level	Stationarity at first difference	Level of Significance
ELECT_SP	I(0) 1.720	I(1) 6.647	2.923
ELECT_T	I(0) 2.380	I(1) 4.873	2.921
GDPG	I(0) 5.612	I(1) 10.716	2.922
PER_CAP	I(0) 1.033	I(1) 2.031	1.952

Source: Eviews 10.0

The unit root test resulted from the Augmented Dickey Fuller (ADF) approach. In this study, the ADF technique was used instead of the Phillip-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) methods since the unit root test produced superior results. The findings demonstrate that, while electricity supply (Elect_Sp), electricity tariff (Elect_T), and per capita income (Per_Cap) were not stable at the level, they were all stationary at the first difference, which has an order of I(1). While GDP was stagnant at a level of I(0). As a result, it contains a combination of I(1) and I(0). As a result, the Bounds test of co-integration outperforms the Johansen co-integration approach.

Co-integration Test (Bound Test)

The bounds test was used because Johansen co-integration has limitations in examining the long-run connection between energy supply, electricity tariff, per capita income, and GDP. This is because the limits test allows for the inclusion of a combination of I(0) and I(1) variables as regressors, which implies that the order of integration of the relevant variables may not always be the same. The autoregressive distributed lag (ARDL) bounds test was performed to establish whether there is a long-run relationship between these variables.

The following hypothesis is given to establish the long-run connection between the variables:

$H_0 = \beta_1 = \beta_2 = \beta_3 = 0$ (no long-run relationship)

Against the alternate hypothesis

$H_0 \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq 0$ (a long-run relationship).

Decision Rule

If the calculated F-statistic is less than the lower restrict value, the null theory is not rejected and no long-run relationship is detected. A long-term association exists if the calculated F-statistic is greater than the upper bound limit. If the estimated F statistic falls between the lower and upper bounds, the results are inconclusive

Table 2

Bounds Test for Cointegration					
Test Statistic	Value	k	Significance	Critical Value Bounds	
				I(0) Bound	I(1) Bound
F-statistic	1.117305	4			
			10%	2.37	3.2
			5%	2.79	3.67
			2.5%	3.15	4.08
			1%	3.65	4.66
Source: EViews, 10.0					

The estimated F-statistic is less than the lower bound value, therefore the null hypothesis is not detected, and it is plausible to conclude that there is no long-run association between electricity supply and independent factors. However, if the predicted F-statistic is greater than both the upper and lower limit values, the components of electricity supply on independent factors share a long-run level connection. If the anticipated F-statistic sits between the lower and upper bounds, the results are confusing. The bound co-integration test findings show that neither the null nor the alternative hypotheses are accepted at the 5% level of significance. The calculated F-statistic of 1.117305 falls between the bottom and upper critical bound values at 5%, the Co-integration Test (Bound Test) demonstrates that there is a long-run steady-state link between electricity supply and electricity tariffs in Nigeria.

Table 3 ARDL Cointegrating and Long Run Form

Cointegrating Form (Short run coefficient)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
ELECT_SP(-1)	0.770312	0.134282	5.736528	0.0000
ELECT_T	6.028609	10.80983	0.557697	0.5820
GDPG	10.96171	17.90491	0.612218	0.5459
PER_CAP	-0.138826	0.080718	-1.719892	0.0978
CointEq(-1)*	-0.229688	0.090227	-2.545657	0.0175
Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
ELECT_T	26.24697	54.51277	0.481483	0.6344
GDPG	47.72437	78.22202	0.610114	0.5473
PER_CAP	-0.604413	0.463783	-1.303224	0.2044
C	2367.123	1048.106	2.258477	0.0329

Source: EViews, 10.0

Error Correction Regression Using the ARDL the cointegrating form demonstrates that the error correction term's (ECT) value is negative and highly statistically significant, demonstrating that the system is stable enough to converge to long-run equilibrium in the wake of certain shocks or disturbances. The disequilibrium was corrected and brought back to equilibrium at a rate of 22.9% during the course of the next year, according to the ECM value, which was about 22.9%. Based on the findings presented in Table 3, it can be concluded that the relationship between electricity supply and electricity tariff, as well as the gross domestic product growth rate, is not statistically significant. Moreover, the impact of electricity supply on these variables is deemed favorable over both short-term and long-term periods. The present findings evince that a mere augmentation of 1% in electricity provision engenders a concomitant elevation of 6.0% in electricity tariffs, as well as significant surges in the growth proportion of gross domestic product, constituting 10.9%, 26.2%, and 47.7%, respectively. The aforementioned implies that a temporary surge in the power supply has resulted in certain favorable, albeit limited, advancements in the economic sphere. The gross domestic product (GDP) and electricity tariffs remain unaltered despite the prevailing circumstances, while the power supply exerts a discernible influence. The findings indicate that an increase in power supply leads to a concomitant rise in both electricity prices and GDP. Nonetheless, the impact of this phenomenon has not been found to be statistically significant. Although the availability of power is present, it has an inconsequential effect on per capita income. The present evidence indicates that augmenting the energy supply has not yielded favorable outcomes in the immediate term. Specifically, a minute rise of 1% in power provision will lead to a reduction in per capita income ranging from 0.1% to 0.60%. The association between the accessibility of electricity and per capita income is relatively insignificant in both the short and long periods. The findings indicate a negative correlation between per capita income and electricity accessibility, whereby an increase in the latter results in a decrease in the former. The potential causality of incongruent outcomes may be attributed to variances between Gencos and Discos in regards to electricity generation, transmission, and pricing. The statistical significance of the overall F-statistics can be inferred from the data. Based on the coefficient of determination R2, which yielded a value of 0.7795, it can be deduced that the explanatory variables incorporated in the models effectively accounted for a significant proportion of the overall change in electricity supply in Nigeria; specifically, 77.9%. Conversely, the remaining 22.1% of the change remains unexplained, which is manifested by the error term. The R2 coefficient indicates that the model aligns with the dataset to a satisfactory degree. The adjusted R-squared coefficient, denoted by a value of 0.7795, provides evidence that the alterations in the independent variables elucidate up to 77.9% of the structured fluctuations observed in the electricity supply, while the residual term accounts for the remaining 22.1%. It is therefore rational to infer that the analyzed explanatory factors demonstrate a strong correlation with the outcome variable, thereby supporting the model's reliability and validity. The statistical evaluation of the Durbin-Watson test, yielding a score of 1.9023, demonstrates the absence of autocorrelation between the variables.

Diagnostic tests

The residual was subjected to certain diagnostic tests in order to evaluate the panel data model under consideration. Breuch-Godfrey serial correlation, Lagrange multiplier (LM) tests, Ramsey reset tests, and the Cumulative Sum (CUSUM) parametric stability test are among the tests performed.

Table 4: Diagnostic Test

Diagnostic Tests Results				
Breusch-Godfrey SerialCorrelationLM Test	F-statistic	0.079051	Prob. F(2, 23)	0.9242
	Obs*R-squared	0.204812	Prob.Chi-Square(2)	0.9027
Heteroskedasticity Test:Breusch-Pagan-Godfrey	F-statistic	2.480754	Prob. F(5, 25)	0.0697
	Obs*R-squared	8.524192	Prob.Chi-Square(9)	0.0742
Ramsey Reset test	t-statistic	1.8588120	Prob.	0.0755
	F-statistic	3.452610		0.0755

Source: E-Views, 10.0

According to the findings presented in Table 4, it can be inferred that the diagnostic tests conducted have substantiated the model's validity in addressing any potential issues related to serial correlation, functional form misspecification, or non-normatively distributed errors. The statistical assessment revealed that the data did not satisfy the conditions of autocorrelation and heteroscedasticity at a 5% significance level. Therefore, it can be inferred that autocorrelation and heteroskedasticity are absent from the model.

Stability Tests

In the investigation of the durability of the long-term coefficients in tandem with the short-term dynamics, the analytical tools employed are the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ). Moreover, the stability of the coefficients over the sampling period is demonstrated through the application of the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) graphical displays derived from a recursive estimation of the model. These plots are depicted in Figures 1 and 2.

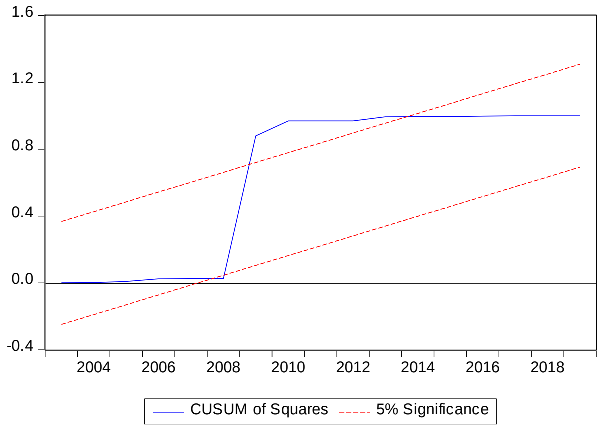

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Fig. 1: Cumulative Sum (CUSUM) **Fig. 2: Cumulative Sum of Squares (CUSUMSQ)**

Source: E-Views, 10.0

The Cumulative Sum of Recursive Residuals (CUSUM) graph indicates that the model's residuals remained within the confines of the established upper and lower bounds from 1971 to 2021, as depicted in Figure 1. The present study investigates the unpredictability of the total electricity supply, electricity tariff, gross domestic product, and per capita income in relation to economic development over a certain period, specifically between 2010 and 2015. The cumulative sum of squares (CUSUMQ) depicted in Figure 2 demonstrates this phenomenon. Between 2010 and 2015, the residuals of the model were observed to surpass the 5% critical threshold. The volatile trend manifested as a result of alterations in the structural framework and diminished gas reserves resulting from fluctuations in worldwide gas prices, noting that gas remains a primary and dominant source of electricity generation in Nigeria, comprising over 70% of the country's total production. In addition, mismanagement of the country's abundant energy resources account for the fluctuations been seen in the volatile trend.

5. Conclusion and Recommendations

The principal objective of this paper is to assess the causal correlation between the supply of electricity and the respective electricity tariff through the application of the autoregressive distributed lag (ARDL) technique, with the aim of scrutinizing the data utilized in the present study. This study is essential due to the crucial role that electricity plays in contemporary life; thus, electricity supply shortages has chain effect on all sectors of the economy. It serves a multitude of purposes, including occupational, transportation, communicative, health-oriented, educational, and residential applications such as lighting, culinary practices, and thermal regulation. As such, the empirical investigation holds significant value in understanding the usage and impact of electricity supply in various domains. The study indicated that electricity tariffs constitute a decisive factor in determining the extent of electricity supply in Nigeria. The impact of per capita income on electricity supply is found to be inconsequential, suggesting an inelastic characteristic of energy consumption. Hence, the lack or insufficient provisioning of energy can result in significant ramifications for households, commercial enterprises, and the larger economy. The result of the ARDL estimate revealed that electricity supply has, both in the short-run and long-run, an insignificant positive effect on the electricity tariff and gross domestic product, while having an insignificant negative effect on per capita income in Nigeria. Therefore, the underperformance of the electricity sub-sector can be attributed to several factors, including a monopolistic market structure, an inadequate regulatory framework, a significant investment gap, decaying and insufficient infrastructure, suboptimal pricing, revenue drainages, substantial aggregate technical collection and commercial losses, and deficient management practices. Consequently, the study arrived at this recommendation that it is fundamentally imperative for the advancement of the Nigerian electric power provision enterprise to implement an electricity cost-tariff system that achieves equilibrium between the interplay of supply and demand while guaranteeing a viable return on investment. The adoption of electricity tariffs that reflect costs would provide a comprehensive solution for eliminating the monthly subsidies that have been disbursed to offset deficits in electricity tariffs over the years. This gap has been exacerbated by the government's intervention in the electricity market and its regulation of the tariffs or pricing framework, which is acknowledged to be a contingent liability of the government. The citizenry of Nigeria exhibits a proclivity for accepting the cost-reflective tariff, in contrast to incurring the financial burden of generating electricity autonomously, subject to the condition that the energy sector assures the provision of easily accessible and dependable electricity.

Furthermore, to completely optimize the endless vitality assets of Nigeria, it is prescribed that the control segment experience total privatization so as to invigorate broad private speculation within the auxiliary control sectors. This will result within the development of power supply to basic segments of the economy. In parallel, the Government of Nigeria ought to seek after a vigorous part within the transmission sub-sector of the Nigerian Power Supply Industry (NESI) to improve its proficiency within the brief term whereas steadily moving towards total privatization. The burgeoning energy market presents sizeable prospects for domestic and international investors alike, as their engagement would help ameliorate the considerable investment disparity in the transmission and distribution subfield, alongside the electrical scarcities engendered by swift demographic expansion.

To reduce loss of electricity, thus, the implementation of state-of-the-art technology in the transmission and distribution of electrical power would potentially curtail electricity loss, mitigate the concerns arising from the surge in consumption (thereby reducing congestion), and enhance the quality of electrical supply in Nigeria notwithstanding the constant growth of its population. Finally, a nation grappling with severe challenges pertaining to the multidimensional poverty index, suboptimal resource management, prevalent instances of unemployment, and a low level of per capita income Hence, the development of an electricity tariff that accurately reflects costs and services rendered is of utmost importance. Such a tariff would serve as a catalyst for increased private sector involvement in power sub-sectors, ultimately fostering the provision of high-quality and reliable electricity to key sectors of the economy.

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