Atiku, Abubakar Mohammed; Suraya Ismail; Roslan, Farah et al.

Article

The effect of electricity distribution loos, electricity power consumption, electricity intensity on energy consumption in West Africa

International Journal of Energy Economics and Policy

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Atiku, Abubakar Mohammed/Suraya Ismail et. al. (2022). The effect of electricity distribution loos, electricity power consumption, electricity intensity on energy consumption in West Africa. In: International Journal of Energy Economics and Policy 12 (5), S. 361 - 369.
https://econjournals.com/index.php/ijeep/article/download/13386/6940/31236.
doi:10.32479/ijeep.13386.

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2022, 12(5), 361-369.

The Effect of Electricity Distribution Loss, Electricity Power Consumption, Electricity Intensity on Energy Consumption in West Africa

Abubakar Mohammed Atiku[1]*, Suraya Ismail[1], Farah Roslan[2], Ali Umar Ahmad[3]

[1]Faculty of Business and Management, Universiti Sultan Zainal Abidin (UnISZA), Terengaennu Malaysia, [2]Faculty of Fundamental Studies, Universiti Sultan Zainal Abidin (UniSZA), Malaysia, [3]Faculty of Maritime Study, Universiti Malaysia Terengganu, Malaysia. *Email: Abbaktn@gmail.com

Received: 16/06/2022 **Accepted:** 01/09/2022 **DOI:** https://doi.org/10.32479/ijeep.13386

ABSTRACT

This paper analyses the effect of electricity distribution loss, carbon emissions, growth, and energy consumption nexus in West Africa utilising pooled series data that spans the decades of 1970 to 2019. The paper employs cross sectional auto regressive distributive lag model (CS-ARDL), and Dumitrescu Hurlin Causality Test. The result of unit root test reveals that the variables have mixed stationary. In addition, the empirical analysis revealed a statistically significant negative relationship between electricity distribution losses on energy consumption while electricity intensity level, electricity power consumption and economic growth prevails positive on energy consumption in the log-run. The result established a unidirectional causal relationship running from energy consumption LEC to electricity distribution losses LEDL while a bidirectional relationship was found between electricity intensity level LEIL causing LEPC electric power consumption and carbon emission LCO2.

Keywords: CS-ARDL, Dumitrescu Hurlin Causality, Electricity Distribution Loss, Electricity Intensity
JEL Classifications: B23, B23, Q43, Q43

1. INTRODUCTION

There are numerous recurrent literatures about the linkage between energy electricity and energy growth related in recent years. The connection between the two has also been both proven to have a strong relationship theoretically. The ability to produce, store, and transport various forms of energy, which may support an array of economic activities, is crucial to economic progress. Consequently, aligning energy policy with environment, economy, and public health will aid in achieving energy efficiency, an increase in the quality of life, and an increase in the standard of living (Mezghani and Ben Haddad, 2017). However, there exists other integral component that makes both electricity efficiency and stability possible. The likes of electricity distribution, transmission and its final consumption due to the fact that energy is equally a vital component of production as land, labor and capital sustained economic growth. This connection is considerably much higher for electric power energy than it is for overall energy itself (Ikeme and Ebohon, 2005). Although, demand for global electric power consumption declined between 2.5% and 4.5% in the first quarter of 2020, due to lockdown policies that limited the utilization of electric power consumption for most nations, the West African experience remain worrisome because <50% of the region demand is met. Worse still, more than 30% of the regions generated power is attributed to distribution losses (Energy, 2020). Some fundamentals issues with regard to efficiency in demand and supply for electricity are been ignored and as a result, the vacuum of electricity operations is growing wider (Okoye et al., 2021). Transmission and distribution losses expenses paired with technical losses aggregate technical and commercial losses, for most African nations, electricity power has been perceived as a conventional right of citizens by the government not as a commodity to be purchased and consumed. Thus, the transmission and technical losses are accountable for many issues, including power theft that causes a large loss for the corporation. Power theft manifests itself in a variety of ways, including illegal connections for tapping distribution lines, unpaid and under-paid consumer bills, and the refusal of labor union leaders, politicians, farmers, and slum residents to pay exact billing prices (Saini, 2018). Accompanied by old direct current (DC) generators which were linked to loads at the same voltage in the early days of power delivery. However, the advent of alternating current (AC) as a method of generating power fundamentally altered the situation, transformers in installed power stations helps transformer-installed substations decrease it to the supply loads there by reducing technical losses (Nweke and Ngwuta, 2016).

There have been several occasions when distribution firms have been unable to recover the full cost of the power transmited due to illicit electrical consumption by users and erroneous reporting by their own workers. As a result, the potential price is not obtained, and the company's revenue falls short. Consequently, electricity loss encompasses major distribution lines, distribution transformers, subsidiary distribution lines and losses in service to individual users in the distribution system (Ogliari, 2016). The losses we see are caused by a combination of factors: length of distribution line networks; length of low voltage distribution lines; size of distribution transformers; poor power factor; inadequate conductor size; and substandard service wire (Alam et al., 2004). Additionally, there are also losses in the distribution network due to the cables that form the network's grid. Similarly, there are losses in the distribution network due to the networks that support them. Smart meter losses and other components are also losses mostly in distribution network. While, substation losses, distribution transformer losses, customer connection losses, and other component losses all occur on the bus of a distribution network (Fourie and Calmeyer, 2004). Against the background, the aim and objective of this paper is to analyses the effect of electricity distribution losses, carbon emissions, growth, and energy consumption. This is owing to the fact that the studied region has been severely faced with challenges of energy use and has been termed globally energy poor region. Despite the series of scholarly articles undertaking, it appears there are few literatures on electricity distribution loss on energy consumption specifically in the West African region (Ikeme and Ebohon, 2005; Mensah et al., 2021; Opoko and Asinobi, 2021; Pineau, 2008). While few other Spartan related literatures that did not capture distribution loss in their study mostly from middle east and Asia (Alam et al., 2004; Altinay and Karagol, 2005; Hamdi et al., 2014; Saini, 2018; Samu et al., 2019). For this reason, we assume a separate approach to examine empirically the effect of electric power distribution losses using a combination of unique variables such as electricity intensity level and electricity consumption per capita that could possibly explain energy demand model. In addition, we incorporate gross domestic product and carbon emission as control variables. Thus, the paper is decentralized in to five segments. Starting with introduction, followed by literature review, accompanied with materials and method, tailed with result and discussion and finally summary and conclusion.

2. LITERATURE REVIEW

Although, there hasn't been explicit theoretical model relating energy consumption yet a large number of empirical investigations have expressed a linkage between the two from the works of Kraft and Kraft in 1978. However, energy economics has gained a fascinating attention across different scholars of different school of though. Consequently, giving rise to a series of conclusions from different method of analysis (causal, multivariate, and bivariate) growth led hypothesis, conservative and the feedback hypothesis. While ecological and environmentalist presumes the existence of environmental Kuznets hypothesis. However, Saini (2018) explore the scenario for power distribution loss in India, utility losses in feeder lines, mostly associated to power theft through illegal network wiring, vandalism. However, effect becomes enamours Because of the disparity in the accounts, feeder lines are facing massive losses. Altinay and Karagol (2005) examine the link between the amount of electricity used and the actual level of economic output in Turkey throughout the 50-year period from 1950 to 2000. The Zivot and Andrews tests revealed that both series were stagnant around a structural breach. Thus, two distinct approaches were used to assess Granger non-causality: The Dolado-Lutkepohl test with levelled VARs and the traditional Granger causality test using a time series data. Both studies established a strong case for unidirectional causation between electricity usage and income. This suggests that power supply is critical to meeting rising energy usage and hence to sustaining Turkey's economic development.

While in Africa, Onabote et al. (2020) studied the long-run effect between economic development and sustainable energy in Nigeria, as well as the various funding alternatives available for sustainable energy. This objective of the study was accomplished with the help of the Johansen Co integration test. The results indicated that the various forms of sustainable energy and funding used in Nigeria had a variety of implications on the country's economic development. All three factors were also shown to have a long-run association. Furthermore, Nathaniel and Bekun (2021) examines the relationship between power usage, urbanisation, and economic development in Nigeria using a series scope between 1971 and 2014, The study employs the Bayer and Hanck co integration tests and empirical evidence reveals electricity use contributes to overall economic development, although growth inhibited by urbanisation seems to occur at a slower rate. The Granger causality test confirms the neutrality hypothesis for the variables in the short run, whereas the feedback hypothesis is applied to the long-term relationships. While, assess the effect of changes in energy consumption interest rate and import on household consumption in Nigeria taken a time series data from 1985 to 2018. The study employs a log linear model flanked with generalized method of moment and findings suggest neutrality hypothesis. Furthermore, Li and Musa (2021) analyse the relationship between economic growth, energy consumption, and carbon emissions among G20 nations from 1992 to 2014. For robustness, the study utilized the CCEM and AMG regression estimators which suggest that GDP and energy use are associated with carbon emissions. Finally, rapid urbanisation and foreign direct investments raised the rate of nations' CO_2 emissions. Feedback causation between economic development and CO_2 emissions; energy consumption and CO_2 emissions; and between urbanisation and CO_2 emissions were thus disclosed. Conversely, foreign direct investments have been shown to cause CO_2 emissions. Nevertheless, Momodu (2018) examine the nonlinear relationship between electricity generation, energy use and carbon emission in West African states using low carbon model and base run simulation to test for generation adequacy and greenhouse gases emission. Empirical outcome reveals evidence of growth led hypothesis in West African state. On the same note, Gnansounou et al. (2007) uses PLANELEC-Pro is used to study the long-term outlook for a regional energy system built from the bottom up and to study the many benefits the system, using autarkical integration methodology as an alternative to the existing tactic system. The primary conclusion is that regional integration will provide more advantages than autarky, with respect to lower operating costs, decreased power supply cost, and increased system dependability.

3. EMPIRICAL MODEL, DATA AND METHODOLOGY

We apply the cost minimization approach to the energy demand function by using the Cobb-Douglas production function, which relates output to production parameters as adopted by (Hasanov and Mikayilov, 2020). The study implores the annualized pooled series data for the observed countries with the principal objective of examining the effect between electricity distribution loss, carbon emissions, growth, electricity intensity level, and electricity consumption on energy consumption in West African states. The model incorporates other relevant variables like carbon emission intensity, energy intensity and economic growth.

$$Q = AK^{\emptyset} L^{\gamma} E^{\partial} W^{\alpha}$$

Given the Cobb Douglass production function, it is reasonable to assume that a cost function exists as a dual function of the production function, and output largely depends on relative contribution of substitution effect. Consequently, the economy reflects on contestant return to scale and thus, demand and supply for goods and services determine price and income level

$$\beta_0' = \frac{\left[-lnX + \alpha ln\left(\frac{p}{\Phi}\right) bln\left(\frac{y}{d}\right) aln\left(\frac{y}{g}\right)\right]}{\varnothing + \beta + \alpha + \gamma}$$

$$\rho_0 = \frac{\varnothing}{[a + \propto + \delta + \theta]} = \gamma_0 \frac{\delta}{[a + \propto + \delta + \theta]} = \beta_0' = \frac{\alpha}{[a + \propto + \delta + \theta]} = \lambda_0' = \frac{\varnothing - \alpha - \delta}{[a + \propto + \delta + \theta]} = k_n' = \frac{1}{[a + \propto + \delta + \theta]}$$

Where: ∅,α,δ reprset positive values. Hence, we formalized the model in to econometric form:

$$B_0 + BI_{xi} + B2_{X2} + B3_{x3} + B4_{X4} + Bn_{xn} + \mu$$

By taking the natural logarithm of the equation and incorporating the variables, we deduce it to

$$EC = B_0 + lnEDL + lnEPC + lnEIL + lnGDP + lnC02 + \varepsilon$$

Where
EC= energy consumption proxy in oil equivalent per capita
EDL= electricity distribution loss
EPC= electric power consumption per capita
EIL=electricity intensity level C02= carbon emission intensity

Data source: World development indicator

3.1. Cross Sectional Dependency Test

It has been widely observed in every panel analysis models are prone to show evidence of interdependence across series with errors which are likely to prevail because of widespread shocks and un observed components that eventually become a part of error term with spatial dependence, and idiosyncratic pair wise dependence in disruptions with no discernible pattern of typical components or spatial distribution (Chudik and Pesaran, 2013).

$$CD = \sqrt{\frac{2N}{n(n-1}} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \frac{(N-m)\dot{\aleph}_{ij}^2 - r\left[\left((N-m)\dot{\aleph}_{ij}^2\right)\right]}{var\left[\left((N-m)\dot{\aleph}_{ij}^2\right)\right]} \ldots(3)$$

3.2. Testing Slope Homogeneity

We utilized the Pesaran and Yamagata heterogeneity test (2008) to capture slope homogeneity between the cross-sections of the series. This test is also an advanced specification to the normal traditional homogeneity measurements, The P&Y slope homogeneity test was therefore used in this analysis (Erdoğan et al., 2019; Le et al., 2020; Ahmad, et al., 2020a; Jakada et al., 2020a; Jakada et al., 2020b; Farouq, et al., 2021). This test expresses the empirical model as:

$$\bar{\delta} = \sum_{i=1}^{\tau} (\bar{\alpha}_i - \bar{\alpha}_{WFT})' \frac{E_i' J_t B_i}{\dot{\delta}_i^2} (\breve{\alpha}_i - \bar{\alpha}_{WFT}) \quad (4)$$

In addition, Δ and the $\bar{\nabla}_{adj}$ are specified as:

$$\bar{\nabla} = \sqrt{n}\left(\frac{n^{-1}\bar{\delta} - m}{\sqrt{2m}}\right) \quad (5)$$

$$\bar{\nabla}_{adj} = \sqrt{n}\left(\frac{n^{-1}\bar{\delta} - Y(\bar{\alpha}_{it})}{\sqrt{var(\bar{\alpha}_{it})}}\right) \quad (6)$$

Where $Y(\bar{\alpha}_{it})$=m and $var(\bar{\ }_{it})$ $\frac{2m(n-m-1)}{}$

3.3. Panel Unit Root Test

In order to verify stationarity of variables, the study implores the second "generations' of panel root unit tests. Techniques of the first generation presume that the units in the panel data are unassociated sectionally while the second generation allows panel unit cross-relationship. Furthermore, in comparison to second-generation panel unit root checks, a null hypothesis of non-stationarity is assumed Pesaran et al. (2007).

$$\Delta B_{i,t} = \pi_i + \omega_i B_{i,t-1} + \delta \overline{B}_{t-1} + \alpha_i \Delta \overline{B}_{i,t} + \varepsilon_{it} \quad (7)$$

Similarly, the CIPS statistic as:

$$\overline{B}_{t-1} = \frac{1}{n}\sum_{i=1}^{\tau} B_{i,t-1};\ \Delta \overline{B}_{i,t} = \frac{1}{n}\sum_{i=1}^{\tau} B_{i,t-1}\Delta B_{i,n} \quad (8)$$

$$CIPS(n,N) = \frac{1}{\tau}\sum_{i=1}^{\tau}(n,N)n_i \quad (9)$$

Where

(n,N) t_i Indicates the t statistic of ω_i

3.4. Panel Co-integration Test

This research used co-integration tests to determine the long-term relationship between the variable in both models. Due to its model applicability, the Westerlund co integration test is significant. In addition, the test deals with cross-sectional dependence. The Westerlund test uses four statistics of the experiments. The remaining two reflect statistics from the classes (Gt and Ga) (denoted by Pt and Pa).This test assesses the common factors responsible for CSD by taking the averages of every variable in the cross-sections. Due to its flexibility to various cross-section combinations and time periods, this test has increased capacity. In addition, the test enables the panel data to be structurally split. The co integration test panel presented in the following error correction equation was created by Westerlund (2007):

$$\Delta L_{i,t} = \partial_i' \pi_t + \alpha_i \left(R_{i,t-1} - \gamma_i' L_{i,t-1}\right) + \sum_{j=1}^{m} \delta_{ij} \Delta R_{i,t-j} + \sum_{j=0}^{m} \beta_{ij} \Delta L_{i,t-j} + \varepsilon_{i,t} \quad (10)$$

The Gτ and Gα statistics are used to check if co integration occurs in at least one cross-sectional unit, and they are computed as:

$$G_\tau = \frac{1}{\tau}\sum_{i=1}^{\tau} \frac{\breve{\alpha}_i}{Se(\breve{\alpha}_i)} \quad (11)$$

$$G_\alpha = \frac{1}{\tau}\sum_{i=1}^{\tau} \frac{T\breve{\alpha}_i}{1-\sum_{j=1}^{m}\breve{\alpha}_{ij}} \quad (12)$$

The statistics P_τ on P_α and are used to examine if the whole panel involves cointegration and the formulas are presented in Eqs. (13) and (14):

$$\frac{}{Se(\ )} \quad (13)$$

$$\breve{\alpha} = \frac{P_\alpha}{T} \quad (14)$$

Gt and Ga define the statistics of the group. Pt and Pa are the statistics of the panel. The error correction parameter (α α) can be determined by setting the value of the equation (13) $P_\alpha = T\breve{\alpha}$ (14). Consequently, the constraint for error correction is $\breve{\alpha} = \frac{P_\alpha}{T}$, which signifies the proportion of the error to be corrected annually, in case the short-term disproportion happens.

3.5. Cross Sectional Auto Regressive Distributive Lag (CSARDL)

Cross sectional auto regressive distribution lag (CSARDL) estimate is employed not only for robustness but also to check mate the in consistencies of the first-generation methods of estimation bearing in mind the chances of occurrence of heterogeneity and cross-sectional dependency in the series. Thus, to restrain issues of spurious result, the study adopts the cross sectional auto regressive distributive lag estimates (CSARDL)

$$GDP = \propto 0 + \sum_{j=1}^{jp-1} \gamma it GDPit_j PC + \sum_{j=1}^{jp-1} \delta it Xit\_{}_j + \sum_{j=0}^{p} \sigma it Zit\_{}_j + \mu\tau \quad (15)$$

Where: Zt =(ΔECit,Xit,) reflecting a change in economic growth been the dependent variable and Xit representing a change in all the independent variable.

$$\Delta LNGDP_{it} = \acute{a}1 + \sum_{j=1}^{p-1} \partial_{ij} \Delta LNEC_{it-j} + \sum_{1=0}^{q-1} \gamma_{ij} \Delta LNET_{ij-1} + \sum_{1=0}^{r-1} \alpha_{ij} \Delta LNC02_{ij-1} + \mu\tau \quad (16)$$

3.6. Panel Causality Test

The study took comfort to utilized the Dumitrescu and Hurlin panel co integration to observe the causal effect between the variables on the dependent variable for both short and long run. Essential behind it isn't just for robustness but its fixed inherit coefficient to synchronize linear autoregressive system heterogeneous cross-sectional procedure. However, the same procedure is repeated across individual K^{th} regressors X_t on Y_t.

$$\Delta LNGDP_{i,t} = \Delta I + \sum_{r=1}^{r} \partial_i^{(r)} \Delta LNET_{i,t-k} + \sum_{r=1}^{r} \gamma_i^{(r)} \Delta LNEC_{i,t-r} + \sum_{r=1}^{r} \delta_i^{(r)} \Delta LC02_{i,t-r} + \varepsilon_{i,t} \quad (17)$$

$$\Delta LNET_{i,t} = \Delta I + \sum_{r=1}^{r} \partial_i^{(r)} \Delta LNGDP_{i,t-k} + \sum_{r=1}^{r} \gamma_i^{(r)} \Delta LNEC_{i,t-r} + \sum_{r=1}^{r} \delta_i^{(r)} \Delta LC02_{i,t-r} + \varepsilon_{i,t} \quad (18)$$

$$\Delta LNEC_{i,t} = \Delta I + \sum_{r=1}^{r} \partial_i^{(r)} \Delta LNEC_{i,t-k} + \sum_{r=1}^{r} \gamma_i^{(r)} \Delta LNGDP_{i,t-r} + \sum_{r=1}^{r} \delta_i^{(r)} \Delta LC02_{i,t-r} + \varepsilon_{i,t} \quad (19)$$

$$\Delta LNC02_{i,t} = \Delta I + \sum_{r=1}^{r} \partial_i^{(r)} \Delta LNET_{i,t-k} + \sum_{r=1}^{r} \gamma_i^{(r)} \Delta LNEC_{i,t-r} + \sum_{r=1}^{r} \delta_i^{(r)} \Delta LGDP_{i,t-r} + \varepsilon_{i,t} \quad (20)$$

Where: ϕI are fixed intercept term, for time. And r indicates the preceding year lag for all the individual series of the pulled data.Also, $\partial_i^{(r)}, \gamma_i^{(r)}, \delta_i^{(r)} and \theta_i^{(r)}$ are the autoregressive values of the slope within individual Countries and: (H_0 $\partial_i^{(r)}, \gamma_i^{(r)}, \delta_i^{(r)} and \theta_i^{(r)} = 0 \forall_{ij} = 1, ..N$) is the null hypothesis.

4. RESULT AND DISCUSSION

We began our empirical discussion with the basic diagnostics checks to ensure the stability and reliability of the captured series. In such manner, we first adopt the Chudik Pesaran cross sectional dependency test followed by a slope homogeneity test which is later complimented by unit root test before embarking on estimation (Jakada, et al., 2022a, Jakada, et al., 2022b, Jakada, et al., 2022c; Jakada, et al., 2022d; Kamalu, et al., 2022).

Table 1 above demonstrate the mean and variance of the pair wise correlation between the cross section of a panel data, by the chudik pesaran coefficients ranging from -0.74 to 3.14 with corresponding p values. Although, some variables appear to be statistically in significant, hence, the table demonstrates the diversity of the panel, reflecting on the model coefficients becoming heterogeneous with a slope that varies autonomously. Additionally, it demonstrates that the series are independent of each other with no direct influence on a country's socioeconomic structural linkages.

The Table 2 demonstrates that there is no indication of homogeneity across observed series with varying slopes weighted by their accuracy. This suggests that the coefficients seen in the pooled data are diverse and statistically significant at both 1% and 5%. The slope homogeneity test was judged necessary to guarantee and validate the absence of evidence of homogeneity across the observed series (Personal and Archive, 2014; Pesaran et al., 2010; Pesaran and Yamagata, 2008; Ahmad, et al., 2015a; Ahmad, et al., 2015b; Ahmad, et al., 2015c; Ahmad, et al., 2015d; Ahmad, et al., 2015e; Ahmad, et al., 2015f; Umar, et al., 2015; Hassan, A., Babafemi, & Jakada, 2016; Kamalu, et al., 2019; Saidu, et al., 2018; Alkhawaldeh, et al., 2020; Ibrahim, et al., 2020; Jakada, et al., 2020c; Jakada, et al., 2020d; Adam, et al., 2021; Atiku, et al., 2021; Umar, et al., 2021; Jakada, et al., 2020d).

Table 3 showing owing to the stochastic nature of the large panel samples, we opt to use the second-generation unit root test to protect the results of the analysis from being skewed or false. The CIPS and CADIF not only detect stationarity in the series, but they also detect all components of auto correlation, trend, and fluctuation in the observed structure as well. Most variables become stationary at first difference, although certain series demonstrate mixed stationarity, the likes of lngdp and lnec. Nevertheless, most variables become stationary at the first difference. However, it is worthy to note the powerful nature of the heterogeneous panel result embedded well-built conjecture of cross

Table 1: Cross-sectional dependency test result

Variable	CD test	P	Correlation	Abs correlation
LNEC	3.14	0.002	0.085	0.389
LNEDL	3.67	0.000	0.099	0.410
LNEIL	−3.69	0.000	−0.100	0.489
LNCO2	−0.74	0.458	−0.020	0.339
LNGDP	−1.57	0.016	0.069	0.418
LNEPC	2.41	0.116	0.042	0.503

Under the null hypothesis of cross-section independence, CD~N (0, 1).

Table 2: Slope homogeneity result

Test statistics	Value	P
$\tilde{\nabla}$	16.582*	0.000
$\tilde{\nabla}_{adj}$	17.910*	0.000

Table 3: Unit root test

Variables	At level	At first difference	
CIFS			
LNEC	−1.1397	−5.254*	I (1)
LNEDL	−1.957	−6.420*	I (1)
LNEIL	−2.142	−5.534*	I (1)
LNCO2	−2.191	−5.804*	I (1)
LNGDP	−4.890*	−6.190*	I (0,1)
LNEPC	−0.949*	−5.929*	I (0,1)
CADIF			
LNEC	−0.949*	−3.937*	I (0,1)
LNEDL	−1.731	−5.366*	I (1)
LNEIL	−2.052*	−4.244*	I (1)
LNCO2	−1.961*	−4.915*	I (1)
LNGDP	−3.911	−5.574*	I (1)
LNEPC	−2.730	−5.682	I (1)

Table 4: Panel co-integration

Statistics	Value	Z	P	Robust P value
Gt	−0.802	5.473	1.000	0.000
Ga	−0.829	4.854	1.000	0.000
Pt	2.526	8.546	1.000	0.010
Pa	2.159	4.574	1.000	0.000

Table 5: Cross sectional auto regressive distributive lag

LNEC						
Variables	Shor-run estimates			Long-run estimate		
	Coefficient	SE	P	Coefficient	SE	P
LNEDL	−0.351 (−18.47)	0.019	0.000	−0.027* (−2.14)	0. 013	0.000
LCO2	0.218 (2.14)	0.102	0.022	−0.172* (−3.37)	0.051	0.000
LNGDP	0.211 (3.91)	0.054	0.000	0.013* (3.25)	0.004	0.000
LNEIL	−0.220 (2.90)	0.110	0.004	0.236 (2.66)	0.089	0.008
LNEPC	0.220 (7.10)	0.031	0.000	0.136 (9.07)	0.015	0.000
Ect	−0.279	0.102	0.006	−	-	-

SE: Standard error

Table 6: Dumitrescu Hurllin causality

Variables	LGEC	LEDL	LEIL	LEPC	LGDP	LCO2
LGEC	-	16.3366*	22.1048*	16.6629*	1.6409	11.5806*
LEDL	2.2806	-	3.1299*	4.1814*	0.6014	2.5059
LEIL	2.0152	0.3402	-	4.5752*	1.1211	1.3149
LEPC	1.2899	−9.855*	4.7719*	-	0.5312	4.0030*
LGDP	2.0990**	0.7810	0.9067	0.8843	-	0.9314*
LCO2	4.5465	10.4622*	7.1986*	12.7989*	1.1782	-

sectional dependency assumed by single common factor (Ahmad, et al., 2018; Ahmad, et al., 2020b; Ahmad, et al., 2020c; Ahmad, et al., 2020d; Dabachi, et al., 2020; Farouq, et al., 2020a; Farouq, et al., 2020b; Jakada, & Mahmood, 2020; Jakada, et al., 2020a; Li, Zhang, Ali, & Khan, 2020; Danmaraya, et al., 2021). Nonetheless, it is reasonable to draw a conclusion and reject the null hypothesis of nonstationarity and test for co-integration.

Table 4 interprets the findings of the westernlund (2007) co integration generated by the equations of the statistical coefficient of Gt,Ga,Pt,Pa with their corresponding probability values. Consequently, the null hypothesis of no co integration was rejected implying the existence of long-term relationship among the observed variables. Nevertheless, the error correction mechanism $\breve{\alpha} = \frac{P_\alpha}{T}$ indicates the rate of conversion to equilibrium per unit increase or decrease in economic distortion. Thus, for every distortion in equilibrium in the short run shall be adjusted commensurately by the values of error correction model. However, the westernlund adaptable and enables nearly full heterogeneity in both long- and short-run specification flanked with bootstrap option (Persyn, 2008).

Table 5 presents the Chudik and Pesaran (2016) cross sectional augmented auto regressive model (CS-ARDL) highlighting the regressed model of energy consumption across the regressors in both short-run and long-run accompanied by the Ect value with corresponding significant p values. The estimate reveals a negative elasticity between electricity distribution losses, energy intensity level in the short-run reflecting weak cost of convergence of energy to output. While the results in the short run show that carbon emission, electric power consumption and gross domestic product have positive coefficients. Looking forward, the long-run estimates confirm a negative relationship between electricity distributions losses on energy consumption, indicating a 1% increase in electricity distribution loss would have a corresponding decrease in energy consumption by –0.27% while 1% increase on energy consumption would lead to an decrease on carbon emission by –0.172%. This is not consistent with the extant literature and our priori expectation as conventional wisdom suggests corresponding increase in both distribution losses and carbon emission with increase in energy use. However, in spite challenging low productivity of industrial operations within the observed region, a number of plausible interpretations can be deduced. Firstly, the studied region has been heavily funded in recent years as an effort to improve electricity access through deployment of high tech alternate current transformers (AC) that consume less energy and increases voltage (Nweke and Ngwuta, 2016). Secondly, the shift on renewable energy solutions like wind turbine and solar thermal has been consistently gaining momentum (Karaki, 2017; Energy, 2020). Thirdly, the emergence of the covid 19 pandemic has resulted to a substantial reduction on energy consumption across the globe. Moving forward, 1% increase in electricity intensity level, electricity power consumption and economic growth indicates 0.236%, 0.136%, and 0.013% corresponding increase in energy consumption respectively. The Ect demonstrate a negative value of -0.279 reflecting on a balanced feedback mechanism of economic distortion in the short-run would converge by the same proportion in the long-run (Table 6).

Given the traditional notion of past values of two or more stationary variables to significantly predict the current value of individual variable i at period t in a panel data model, the study enrolled the Dumitrescu Hurling causality (2012) in other to understand the causal effect between the variables, we test for the significance impacts of previous x values on the current values of y to determining the presence of causation (Lopez and Weber, 2017). Consequently, the empirical outcome discloses the existence of unidirectional causal relationship between electricity distribution loss LNEDL, electricity power consumption LEPC, on LEU energy use which is consistent with the our prior expectation as energy demand increases, distribution losses tend to increase. In other words, as economy expands in population flanked by surge in demand for electricity for domestic and industrial purposes it is natural for the distribution losses to rise (Saini, 2018). While LNGDP causes LCO_2 in a unidirectional way which also justify the core theoretical relationship as evoked by (Begum et al., 2015; Heidari et al., 2015; Rafindadi, 2016). However, bidirectional relationship was found between electricity intensity level LEIL causing LEPC electric power consumption and carbon emission while we observe another unidirectional causation running from carbon emission LCO_2 to electricity intensity and distribution losses. The plausible interpretation to this causation may be inferred to the heating and transfer of energy process in electricity transfer from generation grid to sub-station.

5. CONCLUSION

The economics behind electricity consumption and electricity distribution losses vestiges within the optimal allocation of resources and efficiency in service delivery, as power distributors are presumably to be on the supply side while power consumers remain on the demand side. This study examines the effect of electricity distribution losses, electricity intensity level, and electric power consumption on energy consumption by incorporating economic growth and carbon emission as control variables using CS-ARDL and Dumitrescu Hurling causality. The empirical analysis revealed a statistically significant negative relationship between electricity distribution losses on energy consumption while electricity intensity level, electricity power consumption and economic growth prevails positive on energy consumption in the log-run. The result established a unidirectional causal relationship running from energy consumption LEC to electricity distribution losses LEDL while a bidirectional relationship was found between electricity intensity level LEIL causing LEPC electric power consumption and carbon emission LCO_2. Our result is consistent with (Samuel et al. 2021) for the case of Nigeria and (Ouédraogo, 2010) Burkina Faso. However, it is imperative for policy and decision makers to note that energy intensity level of the studied region tends low indicating lower cost of conversion to output or GDP ratio as reflected on our estimates. Consequently, the negative relationship of distribution losses indicates sign of weak and obsolete grid power transmission coupled with ageing feeder transformers. Thus, policy makers should consider more pro active measures on high green technology gadgetries to tackle modern reality.

REFERENCES

Alam, M.S., Kabir, E., Rahman, M.M., Chowdhury, M.A.K. (2004), Power sector reform in Bangladesh : Electricity distribution system. Energy, 29(11), 1773-1783.

Altinay, G., Karagol, E. (2005), Electricity consumption and economic growth : Evidence from Turkey. Energy Econ, 27(6), 849-856.

Ahmad, A.U., Abdullah, A., Abdullahi, A.T., Muhammad, U.A.A. (2015a), Stock market returns and macroeconomic variables in Nigeria: Testing for dynamic linkages with a structural break. Scholars Journal of Economics, Business and Management, 2(8A), 816-828.

Ahmad, A.U., Abdallah, A., Sulong, Z., Abdullahi, A.T. (2015b), An autoregressive distributive lag for the analysis of macroeconomic variables on stock market returns in Nigeria. Advances in Environmental Biology, ???, 481-502.

Ahmad, A.U., Abdullah, A., Sulong, Z., Abdullahi, A.T. (2015c), The review of stock returns and macroeconomic variables. International Journal of Academic Research in Business and Social Sciences, 5(5), 2222-6990.

Ahmad, A.U., Abdullah, A., Sulong, Z., Abdullahi, A.T. (2015d), Causal relationship between stock market returns and macroeconomic variables in Nigeria. IOSR Journal of Humanities and Social Science, 20(5), 74-96.

Ahmad, A.U., Abdullah, A., Sulong, Z., Abdullahi, A.T. (2015e), The review of stock returns and macroeconomic variables. International Journal of Academic Research in Business and Social Sciences, 5(5), 2222-6990.

Ahmad, A.U., Ismail, S., Ahmad, I.M., Adamu, I.M., Jakada, A.H., Farouq, I.S., Danmaraya, I.A. (2020a), Pollutant emissions, renewable energy consumption and economic growth: An empirical review from 2015-2019. Journal of Environmental Treatment Techniques, 8(1), 323-335.

Ahmad, A.U., Ismail, S., Dayyabu, S., Adnan, A.A., Farouq, I.S., Jakada, A.H., Mustapha, U.A. (2020b), Non-linear causal link between central bank intervention and exchange rate volatility in Nigeria. Global Journal of Management and Business Research, 20(6), 1-14.

Ahmad, A.U., Adamu, I.M., Ahmad, I.M., Ismail, S., Farouq, I.S., Jakada, A.H., Mustapha, U.A. (2020c), Empiric on the relationship between pollutant emissions, renewable energy consumption, and economic growth: Evidence from Sub-Saharan African countries. International Journal of Scientific and Technology Research, 9(1), 1-13.

Ahmad, A.U., Ismail, S., Jakada, A.H., Farouq, I.S., Muhammad, A.A., Mustapha, U.A., Muhammad, A. (2020d), A heterogeneous relationship between urbanization, energy consumption, economic growth on environmental degradation: Panel study of Malaysia and selected ASEAN+ 3 countries. Journal of Environmental Treatment Techniques, 8(1), 573-581.

Ahmad, A.U., Loganathan, N., Streimikiene, D., Hassan, A.A.G. (2018), Financial instability, trade openness and energy prices on leading African countries sustainable growth. Economic Computation and Economic Cybernetics Studies and Research, 52(1), 127-142.

Ahmad, A.U., Umar, M.B., Dayyabu, S., Ahmad, U.G., Danlami, M.R.U. (2015f), Impact of macroeconomic variables on stock market development in Nigeria: Empirical evidence with known structural break. Scholars Journal of Economics, Business and Management, 2(10A), 971-994.

Alkhawaldeh, B.Y., Mahmood, S., Jakada, A.H. (2020), An empirical assessment of the effect of taxes and interest rate on economic growth in Jordan: An application of dynamic autoregressive-distributed lag. Research in World Economy, 11(3), 1-7

Atiku, A.M., Ismail, S., Ahmad, A.U. (2021), Energy trade amidst sustainable economic growth in regional cooperation of West African States: Fresh evidence from panel CS-ARDL. International Journal of Energy Economics and Policy, 11(6), 262-269.

Begum, R.A., Sohag, K., Abdullah, S.M.S., Jaafar, M. (2015), CO_2 Emissions, energy consumption, economic and population growth in Malaysia. Renewable Sustainable Energy Reviews, 41(C), 594-601.

Chudik, A., Pesaran, M.H. (2013), Theory and Practice of GVAR Modeling. University of Southern California, Center for Applied Financial Economics (CAFE) Research Paper Series, (14.04).

Dabachi, U.M., Mahmood, S., Ahmad, A.U., Ismail, S., Farouq, I.S., Jakada, A.H., K., Mohammed, A.A., Mustapha, A.U., Abdullahi, A.T. (2020), Energy consumption, energy price, energy intensity environmental degradation, and economic growth nexus in African OPEC countries: Evidence from simultaneous equations models. Journal of Environmental Treatment Techniques, 8(1), 403-409.

Danmaraya, I.A., Jakada, A.H., Mahmood, S., Ibrahim, B.A., Ali, A.U. (2021), Heterogeneous effect of oil production on environmental degradation: Panel evidence from OPEC member countries. International Journal of Energy Sector Management, ???, ???.

International Energy Agency. (2020), Global Energy Review 2020. France: International Energy Agency.

Erdoğan, S., Gedikli, A., Yılmaz, A.D., Haider, A., Zafar, M.W. (2019), Investigation of energy consumption-Economic growth nexus: A note on MENA sample. Energy Reports, 5, 1281-1292.

Farouq, I.S., Sulong, Z., Ahmad, A.U., Jakada, A.H., Sambo, N.U. (2020a), The effects of economic growth on financial development in Nigeria: Interacting role of foreign direct investment: An application of NARDL. International Journal of Scientific and Technology Research, 9, 6321-6328.

Farouq, I., Sulong, Z., Ahmad, U., Jakada, A., Sambo, N. (2020b), Heterogeneous data approach on financial development of selected African leading economies. Data in Brief, 30, 105670.

Farouq, I.S., Sambo, N.U., Ahmad, A.U., Jakada, A.H., Danmaraya, I.A. (2021), Does financial globalization uncertainty affect CO2 emissions? Empirical evidence from some selected SSA countries. Quantitative Finance and Economics, 5, 247-263.

Fourie, J.W., Calmeyer, J.E. (2004), A Statistical Method to Minimize Electrical Energy Losses in a Local Electricity Distribution Network. In: 2004 IEEE Africon. 7th Africon Conference in Africa (IEEE Cat. No. 04CH37590). Vol. 2. Piscataway: IEEE. pp.667-673.

Gnansounou, E., Bayem, H., Bednyagin, D., Dong, J. (2007), Strategies

for Regional Integration of Electricity Supply in West Africa. Energy Policy, 35(8), 4142-4153.
Hassan, A., Babafemi, O.D., Jakada, A.H. (2016), Financial markets development and economic growth in Nigeria: Evidence from VECM approach. International Journal of Applied Economic Studies, 4(3), 1-13.
Hamdi, H., Sbia, R., Shahbaz, M. (2014), The nexus between electricity consumption and economic growth in Bahrain. Economic Modelling, 38, 227-237.
Hasanov, F.J., Mikayilov, J.I. (2020), Revisiting energy demand relationship: Theory and empirical application. Sustainability, 12(7), 2919.
Heidari, H., Turan Katircioğlu, S., Saeidpour, L. (2015), Economic growth, CO_2 emissions, and energy consumption in the five ASEAN countries. International Journal of Electrical Power and Energy Systems, 64, 785-791.
Ibrahim, G., Mansor, N., Ahmad, A.U. (2020), The mediating effect of Internal Audit Committee on the relationship between firms financial audits and real earnings management. International Journal of Scientific and Technology Research, 9(04), 816-822.
Ikeme, J., Ebohon, O.J. (2005), Nigeria's electric power sector reform: What should form the key objectives? Energy Policy, 33(9), 1213-21.
Jakada, A.H., Mahmood, S. (2020a), An asymmetric effect of economic growth, foreign direct investment and financial development on the quality of environment in Nigeria. The Journal of Management Theory and Practice (JMTP), ???, 5-13.
Jakada, A.H., Mahmood, S., Ahmad, A.U., Garba Muhammad, I., Aliyu Danmaraya, I., Sani Yahaya, N. (2022a), Driving forces of CO2 emissions based on impulse response function and variance decomposition: A case of the Main African Countries. Environmental Health Engineering and Management Journal, 9(3), 1-11.
Jakada, A.H., Mahmood, S., Ahmad, A.U., Ibrahim Sani, A., Turawa Yola, A. (2022b), The effect of economic factors on the quality of the environment in African countries: An application of panel quantile regressions. Environmental Health Engineering and Management Journal, 9(2), 85-95.
Jakada, A.H., Mahmood, S., Ahmad., A.U., Bambale, S.A. (2020b), Heterogeneous moderating influence of economic growth on financial development and environmental quality in Africa. Journal of Critical Reviews, 7(14), 1-7.
Jakada, A.H., Mahmood, S., Ahmad, A.U., Farouq, I.S., Mustapha, U.A. (2020c), Financial development and the quality of the environment in Nigeria: An application of non-linear ARLD approach. Research in World Economy, 11, 78-92.
Jakada, A.H., Mahmood, S., Ahmad, A.U., Faruq, I.S., Mustapha, U.A. (2020d), The effect of oil price on the quality of environment in Nigerian. International Journal of Scientific and Technology Research, 9(3), 1-8.
Jakada, A.H., Mahmood, S., Haron, N.F., Danmaraya, I.A. (2022c), Revisiting the environmental kuznet curve in Africa: The interactive role of financial development in sustainable environment. Journal of Sustainability Science and Management, 17(4), 1-20.
Jakada, A.H., Marmara A.D., Mahmood, S., Ahmad, A.U., Ibrahim, A.S. (2022d), The nexus between financial instability, renewable energy and environmental quality in the presence of structural breaks: Empirical evidence from Nigeria. Studies of Applied Economics, 40(3), 1-10.
Kamalu, K., Binti Wan Ibrahim, W.H., Umar Ahmad, A. (2022), The effect of remittance on human development in the organization of islamic cooperation member countries: Evidence from DCCE AND CS-ARDL. Iranian Journal of Management Studies, 15(2), 405-424.
Kamalu, K., Wan Ibrahim, W.H., Ahmad, A.U., Mustapha, U.A. (2019), Causal link between financial developments, financial inclusion and economic growth in Nigeria. International Journal of Scientific and Technology Research, 8(12), 1-7.
Karaki, K. (2017), Understanding ECOWAS Energy Policy From national interests to regional markets and wider energy access? In ecdpm. Available from: https://ecdpm.org/wp-content/uploads/ECOWAS-energy-background-paper-PEDRO-political-economy-dynamics-regional-organisations-Africa-ECDPM-2017.pdf
Le, H.P., Hoang, H., Bao, G. (2020), Renewable and nonrenewable energy consumption government expenditure, institution quality, financial development, trade openness, and sustainable development in latin america and caribbean emerging market and developing economies. International Journal of Energy Economics and Policy, 10(1), 242-248.
Li, J., Zhang, X., Ali, S., Khan, Z. (2020), Eco-innovation and energy productivity: New determinants of renewable energy consumption. Journal of Environmental Management, 271, 111028.
Li, K., Hu, E., Xu, C., Musah, M., Kong, Y., Mensah, I. A., Su, Y. (2021), A heterogeneous analysis of the nexus between energy consumption, economic growth and carbon emissions: Evidence from the Group of Twenty (G20) countries. Energy Exploration and Exploitation, 39(3), 815-837.
Lopez, L., Weber, S. (2017), Testing for Granger causality in panel data. The Stata Journal, 17(4), 972-984.
Mensah, J.H.R., Silva, A.T.Y., Dos Santos, I.F.S., de Souza Ribeiro, N., Gbedjinou, M.J., Nago, V.G., Barros, R.M. (2021), Assessment of electricity generation from biogas in Benin from energy and economic viability perspectives. Renewable Energy, 163, 613-624.
Mezghani, I., Ben Haddad, H. (2017), Energy consumption and economic growth: An empirical study of the electricity consumption in Saudi Arabia. Renewable and Sustainable Energy Reviews, 75, 145-156.
Momodu, A.S. (2018), Energy use: Electricity system in West Africa and climate change impact. International Journal of Sustainable Energy Planning and Management, 14, 21-38.
Nathaniel, S.P., Bekun, F.V. (2021), Electricity consumption, urbanization, and economic growth in Nigeria: New insights from combined cointegration amidst structural breaks. Journal of Public Affairs, 21(1), e2102.
Nweke, F.U., Ngwuta, J.E. (2016), Electricity distribution and its challenges in Nigeria. INOSR Experimental Sciences, 2(1), 27-31.
Ogliari, E. (2016), Electrical loads and batteries. International Journal of Scientific and Research Publications, 6(6), 554-560.
Okoye, L.U., Omankhanlen, A.E., Okoh, J.I., Adeleye, N.B., Ezeji, F.N., Ezu, G.K., Ehikioya, B.I. (2021), Analyzing the energy consumption and economic growth nexus in Nigeria. International Journal of Energy Economics and Policy, 11(1), 378-387.
Onabote, A., Jolaade, A., Osabohien, R., Otobo, O., Ede, C., Okafor, V. (2020), Energy sustainability, energy financing and economic growth in Nigeria. International Journal of Energy Economics and Policy, 11(1), 433-439.
Opoko, A.P., Asinobi, A.A. (2021), Users' perception of the impact of prepaid metering on their energy consumption behaviour: A case study of Victoria Garden City, Lekki, Lagos State. IOP Conference Series Earth and Environmental Science, 665(1), 012052.
Ouédraogo, I.M. (2010), Electricity consumption and economic growth in Burkina Faso: A cointegration analysis. Energy Economics, 32(3), 524-531.
Personal, M., Archive, R. (2014), A simple new test for slope homogeneity in panel data models with interactive effects. Munich Personal RePEc Archive (60994).
Persyn, D. (2008), Error-correction-based cointegration tests for panel Data. The Stata Journal, 8(2), 232-241.
Pesaran, M.H., Yamagata, T., Pesaran, M.H., Yamagata, T., Fruhwirth, S. (2010), Testing slope homogeneity in large panels To cite this version.

Journal of Econometrics, 142(1), 50.

Pineau, P.O. (2008), Electricity sector integration in West Africa. Energy Policy, 36(1), 210-223.

Rafindadi, A.A. (2016), Does the need for economic growth influence energy consumption and CO_2 emissions in Nigeria? Evidence from the innovation accounting test. Renewable and Sustainable Energy Reviews, 62, 1209-1225.

Saidu, M.B., Ahmed, A.B., Jakada, A.H. (2018), The determinants of long run economic growth in Nigeria. Asian Economic and Financial Review, 8(1), 1-7

Saini, S. (2018), Scenario of distribution losses-a case study from haryana. 8(1), 163-175.

Samu, R., Bekun, F.V., Fahrioglu, M. (2019), Electricity consumption and economic growth nexus in Zimbabwe revisited: Fresh evidence from Maki cointegration. International Journal of Green Energy, 16(7), 540-550.

Samuel, U.E., Rosemary, I.H., Inim, V., Ededem, A.J., Ndubuaku, V. (2021), Energy consumption and sectorial value addition on economic growth in Nigeria. Universal Journal of Accounting and Finance, 9(1), 74-85.

Umar, M.B., Dayyabu, S., Gambo, A., Danlami, M., Ahmad, A. (2015), An empirical study on the relationship between financial intermediaries and economic growth in Nigeria: A cointegration and causality analysis. Journal of Economics and Finance, 6(4), 15-31.

Umar, N., Sambo, I., Ahmad, A.U., Hassan, A. (2021), Financial development and economic growth in Nigeria: New evidence from a threshold autoregressive and asymmetric analysis. International Journal of Business, 8(3), 207-218.