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Energy Trade Amidst Sustainable Economic Growth in Regional Cooperation of West African States: Fresh Evidence from Panel CS-ARDL

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ABSTRACT

This study aims to examine the influence of energy trade, energy use, and carbon emission on economic growth for the period of 1970-2019, in regional cooperation of West African states. This study employed second generation techniques. The results revealed that energy trade increased economic growth in the long run. However, in short run energy trade reduced in economic growth. Besides, energy consumption impeded the economic growth in both short run and long run, while carbon emission increased the economic growth in both short run and long run. The energy crisis of 2014 decreased economic growth. Moreover, the result of interaction term of energy consumption and carbon emission showed positive influence on economic in both short run and long run. In addition, the results of causality showed uni-directional causal relationship from energy trade to economic growth. Policy recommendations can be made, in the sense that policies should be geared towards promoting renewable sustainable energy conservation policy that could possibly improve economic integration.

Keywords: Economic Growth, Energy Trade, Regional Cooperation of West African States, Second Generation Techniques
JEL Classifications: F34, K32, O55, C01

1. INTRODUCTION

Energy has evolved into an important catalyst for propelling society. The power of man to harness sunlight can be traced back to the origins of energy. Wood has been utilized as a source of energy by people from the beginning of time, and people have also been able to exploit the wind, despite the fact that it took millennia to create windmills and water wheels for energy extraction (Hussain and Hassan, 2019; Ahmad., et al., 2020a). The concept of energy trade has always been characterized by a fast expansion of capital markets and the virtual economy, as well as the significant increase in financial derivatives and the excessive flow of speculative impact on the oil market. The prominence of these external elements makes protection of their interests more difficult for some emerging nations, and makes international pipeline building, market supply and regular corporate fusion and takeovers variables more challenging (Waheed et al., 2019). This has led to an unprecedented rise in energy consumption across global economies. Throughout history, both classical and neoclassical philosophies have emphasized the importance of trade as a primary factor of sustainable growth. From Adam Smith's and Ricardo's works to the forefront of current "Heckcher-Ohlin" ideas, the emphasis is on the importance of factor intensity as a base for growth through specialization (Farah and Cima, 2013). Nonetheless, the pace of trade liberalization has accelerated in recent decades. While conventional thinking holds that trade, openness is a significant predictor of rapid economic growth, leading literatures have been ambiguous on the actual relationship between trade openness and rapid economic growth. International trade nexus and energy consumption synergy (Kahia et al., 2016). Consequently, undermining the impact of regional bilateral agreements particularly in African less developed economies (Kyophilavong et al., 2015). Thus, trade openness refers movement of goods produced in home country for consumption or processing across the boundaries of other countries which require energy-efficiency (Kahia et al., 2016). However, early scholars within the ecological school of thought have initiated an argument regarding energy been a key part of factors of production through technological progress. Therefore, the importance of trade towards energy consumption has been extensively hypothesized across many literatures. Firstly, it expands production and economic activities leading via domestic operations which harness exports of a particular nation leading to overall economic boom. Secondly, it paves way for technological diffusion through imports of advance innovations which reduces energy intensity and thirdly, the transitory effect that allows economy to diversify from traditional economic system to a more advanced industrialized economy. However, the West African energy trade has been in existence in millennia, starting from the most energy endowed nations like Nigeria, Ghana, Corte di vore whom are net exporters to weaker countries like Togo, Niger, and Benin among others. Yet, the region has been for long suffered from huge deficits in the supply and distribution of energy. The technical in efficiency of the region to provide energy has continued to draw back public private partnership and capital investment for industrialization (Karaki, 2017). In spite of the region energy resources potential from both exhaustible (oil; gas; uranium) and non-exhaustible sources (hydroelectric power; solar and wind energy). The majority of West African nations rely significantly on thermal power and antiquated power facilities, resulting in some of the world's highest electricity bills Furthermore, transmission and distribution losses are exceedingly significant, exacerbating the situation (Ne et al., 2015). Large power plants that service a wide range of customers are the most cost-effective technique of generating electricity.

Consequently, the continent of West Africa currently has an installed capacity of 10,640 MW of which only around 60% (ca. 6,500 MW) is fully functional and meets demand. At the same time, overall demand is increasing, reinforced by a growing population and urbanization, estimated to be about 22,000 MW, far more than the actual production capacity (Arima, 2019). This variation is accompanied with lofty loses in revenue and mechanical distortions projected at about 21.5% (Mensah et al., 2021). While substantial resources have been invested to promote power generation through a variety of schemes, practically all of them have experienced roadblocks and stumbling blocks in the form of red tape and bureaucratic delays during implementation. Amid few exceptions, of Ghana, Nigeria and Corted'ivore remain largely the providers of electricity through various hydro dams across the region.

Against this background, the crux of this paper aims to analyze the effect of energy trade, energy consumption, and carbon emission on economic growth. Nevertheless, the study observed a series from the year 1971 to 2020; to enable us draw meaningful inferences for both pre and post-colonial evidences within the region. Furthermore, from the year 2000 to 2020 there has been an upward surge in earnings; trade integration and energy consumption in many West African countries have posed a key concern of whether such increase is supported by deliberate policy action as an attempt for sustainable economic development which pose a challenge on policy makers in a bid to achieve energy conservation through trade expansion and diversification due to the non-renewable nature of some energy sources, and carbon emission implication of energy use (Narayan and Smyth; Sadorsky).This has been impelling rationale to delve on energy-trade link. To achieve the above objective the paper is organized in to five sections. section one covers the introduction, chapter two highlights review of existing literatures, section three maintains empirical model, data and methodology, while section four present results and discussion and lastly the fifth section comes with summary, conclusion and recommendation.

2. EMPIRICAL LITERATURE REVIEW

2.1. Energy Trade Openness Nexus

Studies on energy trade have been very meager literature (Adeniyi and Adewuyi, 2019; Duan and Chen, 2016; Opeyemi et al., 2019). Even though, there are vast literatures testing relationships between trade openness and energy consumption. Still yet, conclusion remains quite imprecise. Jing et al., (2020) reviewed and examined energy trade ties of china and the belt road countries using a gravitational analysis of 66 countries across 81 renewable energy products. The study utilizes stepwise regression and empirical evidence reveals a great potentiality of Chinas energy trade on renewable energy to 26 central and East Asian countries. Furthermore, the study observed a surge in on Chinas renewable energy production over the study period. The gravity model is widely studied to explain the impact of trade groups, to determine the impacts of trade and to examine trade flows, and estimate tariffs. Gravity models are frequently utilized in trade studies. Zeren and Akkus (2020) explores the nexus between renewable energy consumption for Bloomberg emerging economies using panel co integration and causality approach, empirical outcome reveal a strong unidirectional connectivity between renewable energy and trade openness. However, Shahbaz et al. (2014), explores the relationship between trade openness on energy consumption using a panel data of 91 low, middle and high income counties. The study however, engaged panel co integration. The result confirms an inverted u shape curve in high income countries and u shape kuznet curve in low- and middle-income counties. While a study by Parsa and Sajjadi (2017) reveals a unidirectional causality was reported between energy consumption and trade openness in the short run while bidirectional causal association from economic growth to energy consumption in the long –run is established in Iran. Using co integration by Bayer and Hanck, VECM (vector error correction mode) intensifying economic growth, energy consumption, and trade openness ware independent of each other in the case of Iran. However, there was a possibility of a unidirectional connection between trade openness to economic growth.

On the other hand, Zameer et al. (2020) took a look into the relationship between innovation, trade on energy in India. The study aimed to investigate the role of technological innovation, FDI, economic openness, and energy use in carbon emissions. Using the 1985-2017 data, the ARDL method was used to capture the impact of technological innovation, trade openness, foreign direct investment, and the use of energy on CO_2 emissions. The research has revealed long-term co integration between trade openness, the use of energy, and economic growth. However, the variable CO_2 emissions is influenced positively by the observed variables. On the other hand, innovation and FDI put a push on carbon dioxide emissions in the long term. Innovation, trade openness, and energy use prevails bi directional towards each other. Whereas, a one-way relation has been discovered between GDP, Foreign Direct Investment, innovation, trade, and carbon emissions has been discovered to be true. In the short term, results from investment, on- FDI, and emission of CO_2 are mutually exclusive. Never the less, Zeren and Akkus (2020) investigates the relationship between trade openness and the consumption of renewable and nonrenewable energy. A formal investigation is carried out on the "top ten countries in the world from 1980 to 2015," in accordance to Bloomberg. The Westerlund test, panel co integration test, and Pesaran's multi-panel predicting with co integration are used to evaluate the causal relationship between the series, with the long-term goal of making a higher sustainable economic growth. The study also was discovered that nonrenewable energy was more common than reusable energy.

2.2. Energy Consumption and Economic Growth

Despite the series of conflicting mixed findings within the energy growth-related works of literature, most results were subjected to empirical challenge, and hence researchers adopt a variety of methodologies across various variables in the spirit of avoiding misleading and conflicting results. However, Romijn (2019) employed a generalized method of moment (GGM) estimates to understand the relation between energy consumption and economic growth for 108 countries. There empirical result affirms the existence of one way relationship from energy consumption to economic growth, indicating growth hypothesis. Likewise, Erdoğan et al. (2019) investigates a panel survey on energy consumption economic growth nexus. The empirical outcome reveals the existence of long-term co integration between the said variables. Confirming growth led hypothesis. Furthermore, it reveals that energy consumption induces economic expansion through industrialization in Cairo, Jordan, and Lebanon. However, appearance of no causality was fund in Saudi Arabia on the variables indicating a neutral hypothesis which also reflects on Tunisia. Consequently, Egypt, Saudi Arabia and Lebanon exhibit growth doctrine detailing an increase in growth leads to more intense energy use. Relatively, Parsa and Sajjadi (2017) explored, the connection between energy use. A special evidence for Thailand Using trade openness as a mediating variable and reported a bidirectional bound between the observed variables. Also, the study shows evidence of a feedback hypothesis. Similarly, Zerbo (2017) examines the relationship between economic growths on energy consumption in sub-Saharan Africa employing a multivariate autoregressive distributive lag model. The study found the existence of a growth hypothesis in Nigeria and Kenya, while the conservative hypothesis was reported for Sudan and Zambia. Furthermore, a feedback hypothesis was established in Cameroon while Benin, Togo, Ghana, and Senegal confirm the neutrality hypothesis.

3. EMPIRICAL MODEL, DATA AND METHODOLOGY

We utilize the neo-classical trade paradigm as the theoretical framework for this analysis. More specifically, the resource endowment model of Heckscher-Ohlin for closed economy as adopted by (Adeniyi and Adewuyi, 2019). The study implores the panel time series data for the period 1970-2019 with the principal objective of investigating the effect of energy trade on sustainable economic growth of regional cooperation of West African states. The model incorporates other relevant variables like carbon emission, energy consumption and energy trade calculated by estimated energy use less production, both measured in oil equivalents. Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport. Furthermore, we giving the period of the study, we observe a structural break of 2014 energy crisis. The data were sourced from World Bank Indicator (WDI, 2021). Consequently, data sourced from world development indicators. Therefore, the model is presented as follows

$$\text{GDP} = \text{f}\,(\text{EC} + \text{ET} + CO_2 + \mu) \tag{1}$$

And by taking the natural logarithm of the variables;

$$\text{GDP}_{it} = \alpha_{1i} + \alpha_{2i} TB2014_{it} + \alpha_{3i} LET_{it} + \alpha_{4i} LEC_{it} + \alpha_{5i} LC02_{it} + \varepsilon_{it} \tag{2}$$

Where: α_{1i} reprset the intecept term

TB2014it break.

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).

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

3.2. Testing Slope Homogeneity

We utilized the Pesaran and Yamagata (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 and Y slope homogeneity test was therefore used in this analysis (Erdoğan et al., 2019; Le et al., 2020; Jakada, et al., 2020; Jakada, & Mahmood,2020). This test expresses.he empirical model as:

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

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

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 (Ibrahim, et al., 2020;Ahmad, et al., 2018; Adam, et al., 2021). Furthermore, In comparison to second-generation panel unit root checks, a null hypothesis of non-stationarity is assumed. Pesaran et al. (2008).

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

Similarly, the CIPS statistic as:

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

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

Where

(n,N) t_i Indicates the t statistic of $\omega_{i.}$

3.4. Panel Co-integration Test

This research used Westerlund (2007) 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 (Ahmad, et al., 2020b;Dabachi, et al., 2020). 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 cointegration occurs in at least one cross-sectional unit, and they are computed as:

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

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

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

$$P_\tau = \frac{\check{\alpha}}{Se(\check{\alpha})} \quad (13)$$

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

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_α=Tα (14). Consequently, the constraint for error correction is $\check{\alpha} = \frac{P_\alpha}{T}$, 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) estimates is adopted for robustness and 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 issuesf spurious result, the study adopts the cross sectional auto regressive distributive lag estimates (CSARDL).

$$\Delta LNGDP_{it} + \alpha 1 + ZiT + \sum_{j-1}^{p-1}\partial_{ij}\Delta LNEC_{it-J} + \sum_{1-0}^{q-1}\gamma ij\Delta LNET_{ij-1} + \sum_{1-0}^{r-1}\alpha ij\Delta LNCO2_{ij-1} + \mu\tau \quad (15)$$

Where: Zt = (ΔECit,Xit,Zit) effecting a change in economic growth been the dependent variable and Xit representing a change in all the independent variable and maintaining the break coefficient.

$$\Delta LNGDP_{it} + \alpha 1 + ZiT + \sum_{j-1}^{p-1}\partial_{ij}\Delta LNEC_{it-J} + \sum_{1-0}^{q-1}\gamma ij\Delta LNET_{ij-1} + \sum_{1-0}^{r-1}\alpha ij\Delta LNCO2_{ij-1} + \mu\tau \quad (16)$$

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 variable's energy- trade, energy consumption and carbon emission on the dependent variable economic growth 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.

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

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

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

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

Where: ϕI are fixed intercept term, for time. And 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 while $\beta T2014_i$ represent breaks

4. RESULT AND DISCUSSION

Is study began its empirical discussion with the basic elementary 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 latter complimented by unit root test before embarking on estimation.

Table 1 Present the Chudik Pesaran cross sectional dependency test to inspect the mean and variance of the pair wise correlation between the cross section of a panel data. However, the coefficient of the CD test ranges from 1.1, 2.2, 2.4, to 5.4 while the absolute mean deviation between 0.12 and 0.38 as the maximum deviation which reflect the existence of cross sectional dependence across the observed countries with an exception of carbon emission.

The Table 2 above reveals no evidence of homogeneity in the observed series with different slope weighted by their precision. This implies coefficients of the pooled data observe are heterogeneous and statistically significant at both 1% and 5%. It was deemed imperative to undergo the slope homogeneity test to ensure and confirm no evidence homogeneity across the studied countries. (Pesaran et al., 2010 Pesaran and Yamagata, 2008).

Table 3: Owing to the stochastic nature of the large panel samples prompt the study to utilize the second-generation unit root test to prevaricate the analysis from biased and spurious regression. The CIPS and CADIF observe not only stationarity of the series but also all elements of auto correlation, trend and variation of the observed structure. However, some of the series exhibit a mixed stationarity while most of the variable becomes stationary at first difference (Ahmad, et al., 2015a; Ahmad, et al., 2015b; Ahmad, et al., 2015c; Umar, et al., 2015; Alkhawaldeh, et al., 2019; Jakada, 2019;Kamalu, et al., 2019). Nevertheless, it safe to conclude and reject the null hypothesis of non-stationarity.

Table 4 interprets the findings of the Westerlund 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

Table 1: Cross-sectional dependency test result

Variable	CD Test	P value	Average Joint T	Mean ρ	Mean Abs ρ
GDP	1.105	0.269	51.00	0.04	0.12
ET	2.213	0.027	51.00	0.08	0.38
EU	2.44	0.015	51.00	0.09	0.42
C02	5.496	0.000	51.00	0.20	0.24

Under the null hypothesis of cross-section independence, CD ~ N (0, 1) P-values close to zero indicate data are correlated across panel groups

Table 2: Slope homogeneity result

Test statistics	Value	P-value
$\bar{\nabla}$	3.856*	0.000
$\bar{\nabla}_{adj}$	4.061*	0.000

Table 3: Unit root test

CIPS	At level	At first difference	
LGDP	--4.719*	--6.420*	I(0)
LET	−1.653*	−6.002*	I(1)
LEC	−1.262*	−5.631*	I(1)
Lco2	−2.265*	−5.493*	I(1)
Cadif			
LGDP	−4.280*	−5.992*	I(1)
LET	−1.731*	−4.867*	I(1)
LEC	−1.357*	−4.259*	I(1)
Lco2	2.539*	−5.124*	I(1)

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.

Accordingly, after confirming the existence of long-term relationship or co integration the study cossets an estimation procedure with most efficient CSARDL estimates. The results present in Table 5. However, on the short run the only carbon emission appears to be positively significant while the variables energy trade and energy use prevail to be negative relationship yet statistically significant in the short run. This implies that for every 1% increase on the dependent variable LNGDP there would be a corresponding decrease on energy trade by 68% and energy use by 86% in the short run. Consequently, the interaction term prevails to be positive intensifying the high variability of the dependent variable over time. Accordingly, the error correction coefficient indicates 67% rate of conversion to equilibrium in the event of certain economic distortion in the short run. Meanwhile, the long run coefficients for energy trade and carbon emission are positively and statistically significant reflecting on a positive relationship between the dependent variable. In other words, a unit increase in LGDP would increase energy trade and carbon emission by 51% and 39%. This is in line with the findings of (Adeniyi and Adewuyi, 2019; Nathaniel and Bekun, 2020; Parsa and Sajjadi, 2017).

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 in Table 6 discloses the existence of bidirectional causal relationship between LNGDP economic growth and LEU energy use which is consistent with the theoretical baseline confirming the growth led hypothesis. In other words, as economy expands it is natural for the demand of energy use to rise (Adeniyi and Adewuyi, 2019) while LNGP causes LCO2 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, one-way relationship was found between energy trade LNET causing economic growth LNGDP and the plausible interpretation to this causation may be inferred to the surplus revenue generated from the energy exporting countries.

Table 4: Panel co-integration

Statistics	Value	Z value	P value	Robust P value
Gt	−3.537	−2.800	0.003	0.000
Ga	−17.705	−1.518	0.065	0.000
Pt	−8.531	−3.017	0.001	0.010
Pa	−18.916	−3.105	0.001	0.000

5. DISCUSSION SUMMARY AND CONCLUSION

The thirst for sustainable economic growth amidst energy scarcity in West African states have deepen the need for more integrated energy supply for rapid urbanization and industrial expansion. Thus, the study examines of energy trade, energy consumption, and carbon emission on economic growth covering a scope period between 1970 and 2019 using cross sectional ARDL. Result of diagnostic checks like cross sectional dependency and slope homogeneity confirms the existence of heterogeneity in the observed series. Consequently, we observed the series to be having mixed stationarity linking the need for cointegration relationship among the variables. The empirical result suggests a statistically significant relationship across the variables in both short run and the long run. While bidirectional causation was revealed running from energy use and economic growth, a unidirectional causality

Table 5: Cross sectional ARDL

LNGDP						
Variables	Shor-run estimates			Long-run estimate		
	Coefficient	Standard error	P-value	Coefficient	Standard error	P-value
LNET	−0.679* [−4.47]	0.152	0.000	0.511* [3.73]	0.137	0.000
LEC	−0.860* [−4.43]	0.194	0.000	−0.421* [4.90]	0.086	0.000
LCO2	0.100** [2.56]	0.039	0.032	0.391* [4.16]	0.094	0.000
LNEC*LNET	0.111* [4.83]	0.023	0.000	0.618* [4.26]	0.145	0.000
EC_t	−0.670 [−5.34]	0.125	0.000	-	-	-

Table 6: Dumitrescu-Hurlin causality

Variables	LGDP	LET	LEC	LCO2
LGDP	-	−0.3165	5.1577*	7.125*
LET	6.5034*	-	2.3847	4.1814*
LEC	8.2423*	1.9225	-	4.5752*
LCO2	−0.9159	−9.855*	4.7719*	-

was observed between carbon emissions and economic growth. Therefore, regional energy, production and consumption potential already indicates some differences in extending the energy integration and energy for nation like Nigeria that generates around 56% of total power in the country, but has a relatively low rate of access to power (under 50%).

This scenario may be expanded to other affluent countries with energy resources in other nations with low capacity, on the other hand. It is worthy to note that global trade and macroeconomic policies that help stimulate regional exports are inconsistent with the traditional environmental policies as energy efficiency gives rise to a rebound effect. In addition, low marginal energy efficiency (MEE) in production of regional export might be addressed through the adequacy of energy pricing products to guarantee an optimum input mix in the production. It is equally imperative to highlight trade and other macroeconomic policy supporting industry-specific exports is not consistent with energy conservation policies. However, in countries where increased energy consumption promotes exports like Mali and Senegal, it was apparent that revenue implication across trading partners over the years have not been promising which is due to different political and structural rigidities that ignites a trade-off between energy use and energy trade. Thus, policies should be geared towards promoting renewable sustainable energy conservation policy that could possibly improve economic integration.

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