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Analyzing the Linkage between Renewable Energy Consumption and Economic Growth in West Africa

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ARTICLE INFO

Article history:
Received 25 December 2020
Received in revised form
04 March 2021 (1st revision)
18 March 2021 (2nd revision)
Accepted 05 May 2021

Keywords:
ARDL bound test
Economic growth
Energy consumption
Renewable energy
West African countries

ABSTRACT

This study investigates the short-run and long-run relationships between renewable energy consumption and economic growth within the framework of the production function in fifteen West African countries from 2000 to 2018. The study was based on the Autoregressive Distributed Lag- Bounds test approach (ARDL) and vector error correction model (VECM) to examine the Granger causality between the variables. The results of the ADRL model confirm the presence of cointegration among the variables. The findings confirm that in the short-run renewable energy consumption has an insignificant impact on economic growth. However, in the long-run has a significant and positive impact on economic growth as well as a unidirectional causality running from renewable energy consumption to economic growth. Within the global framework, the study implies that the use of renewable energy in the process of economic growth is highly significant. Therefore, findings imply further policies and support to promote renewable energy would be necessary for economic development in West Africa.

1. INTRODUCTION

Energy is essential to economic progress in today's societies; access to energy is a major factor for economic development in developed and developing countries. In recent decades, non-renewable energy sources have been gradually switched to renewable energy [1]. For example, the US Energy Information Administration (EIA) has announced a 48% increase in global energy consumption by 2040. According to the international renewable energy agency (IRENA), the share of renewable energy in final energy consumption should be increased to 66 percent, while the rate of improvement in energy intensity should be increased to 3.2 percent per year to achieve clean and sustainable energy consumption [2].

Every economy needs a modern and efficient energy system to achieve economic development. For West African countries, a large number of the population lacks access to electricity and modern energy services [3]. Access to energy is fundamental for socio-economic development and poverty reduction. West African economic growth rates have been insufficient in most countries to make significant poverty reduction. The West African economy grew by 3.6% in 2019, slightly below the continental average of 4%. West Africa's regional performance needs to be analyzed in the context of Nigeria, which accounts for nearly 70% of West Africa's regional GDP alone and is currently pulling down West Africa's average. Despite this positive growth outlook, there are many risks and considerable uncertainty related to global trade tensions, the normalization of interest rates in advanced economies, and global commodity prices. West African economies also need to address the structural challenges created by persistent fiscal deficits, low rate of employment, and the percentage of the population with access to electricity to achieve the objective of the Sustainable Development Goals [4].

The dynamic interaction between energy consumption and economic growth impacted both the living standards of individuals and the industry development. Economic growth is related to technical changes as well as energy consumption. With advanced technology and living standards development, the energy demand has been rapidly increasing. However, over the growing concern of the environmental effects of burning fossil fuels, the call for a more sustainable resource base has never been greater. Developed and developing countries rely on an assortment of primary energy sources to produce electricity, such as coal, natural gas, biomass, oil, and renewable energy [5]. This study intends to support renewable energy use as a factor of economic growth, especially in the less developed economies.

This paper aims to contribute to the literature due to the absence of consensus in contemporary literature on the relationship between renewable energy and economic growth. Thus, the empirical literature has

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shown mixed results. On the other hand, the literature on renewable energy and economic growth nexus in West Africa has concentrated on the environment using a different method in their studies [6]-[8] and given less emphasis to explore the causalities between renewable energy consumption and economic growth in short-run and long-run. Also, worldwide nations are gradually recognizing the environmental issue, and consequently, they have started shifting from traditional sources of energy to renewable energy. Therefore, most of the contemporary literature on renewable energy and economic growth are linked with the environmental issue. This paper aims to investigate the short-run and long-run relationships between renewable energy consumption and economic growth and study if renewable energy can be used as a factor to ensure economic growth in West Africa.

The first line of our research is based on the Autoregressive Distributed Lag- Bounds test approach (ADRL). The ADRL is applied as an advantageous technique to analyze variables with mixtures of the level of integration than other techniques that require the same level of integration and provide very efficient and consistent results in small and large sample sizes [9]. The second line of researches combines the approaches of the above-discussed streams on the linkages among real gross domestic product, labor force participation rate, capital, the percentage of renewable energy consumption among total final energy consumption, the percentage of the population with access to electricity, and gross fixed capital formation. The Vector Error Correction Model (VECM) has been used to investigate the dynamic linkages between the variables by panel Granger causality test. This paper is motivated by several reasons notably: in recent decades to achieve sustainable economic growth there has been a steady shift from traditional sources of energy to renewable energy; absence of consensus on the exact relationship between renewable energy and economic growth and gap in the contemporary related literature of Africa on renewable energy and economic growth nexus focusing on the environment.

The remainder of the paper is organized as follows: Section 2 presents the literature review. Section 3 describes the dataset and methodology used. Section 4 analyses the empirical results. Section 5 synthesizes the main results and discusses some policy implications.

2. LITERATURE REVIEW

Renewable energy development has attracted the attention of many academic researchers. The causal relation between energy and economic growth varies from one country to another; due to the fact, different economic structures in the countries studied have different energy sources, as well as the type of methodology used for the studies. A significant number of studies have propped up the renewable energy consumption and economic growth nexus based on four hypothesized energy consumption- growth models [10-14].

Referring to the literature on renewable energy, Mafizur and Velayutham [15] explored the relationship between renewable and non-renewable energy consumption and economic growth for a panel of five South Asian countries. The study revealed that there is a unidirectional causality running from economic growth to renewable energy consumption. As per the obtained results, the conservation hypothesis is valid for the South Asian countries. Ozcan, Tzeremes and Tzeremes [16] found that economic growth and energy consumption patterns contribute to the enhancement of countries' environmental performance levels. Finally, the analysis of the dynamic interrelations among countries' energy consumption, economic growth and environmental degradation levels, reveals the necessity to promote sustainable development through coexistence rather than through a trade-off mechanism.

Region development as a process of improving people's welfare in a country can also lead to the decline of the environment quality. The degradation of the environment can be caused by the energy consumption required in the development process, as well as pollution [17]. Likewise, Le, Chang and Park [18] re-examined how energy consumption interacts with economic growth and emissions using panel data of a global sample consisting of 102 countries. They suggested that the use of non-renewable energy consumption significantly raised the level of emissions across different income groups of countries. Their findings suggested that the use of renewable energy sources helped tackle emissions in developed countries but not in developing countries. Maji, Sulaiman and Abdul-Rahim [19] estimated the impact of renewable energy on economic growth in West African countries using panel dynamic ordinary least squares. They indicated that renewable energy consumption slows down economic growth in those countries. Amoah, Kwablah, Korle and Offei [20] investigated the role of economic well-being and economic freedom as drivers of renewable energy consumption using the share of renewables in total energy consumption in Africa. They found evidence that increasing economic well-being in Africa increases the share of renewables in total energy consumption to a point after which it turns negative. Moreover, the disaggregated measures of economic freedom show that both property rights and tax burden decrease the share of renewables in total energy consumption. Kouton [21] explored the potential impact of renewable energy consumption on inclusive growth in 44 African countries. They found that renewable energy consumption has a significant positive impact on inclusive growth in Africa, particularly in African countries experiencing low levels of inclusive growth. Thus, if African countries succeed in making the transition to renewable energy effective, then incredible gains in inclusive growth could be captured, especially in countries with low levels of inclusive growth.

Based on Autoregressive Distributed Lag (ARDL) approach, Yang *et al.*, [22] studied the impact of renewable and non-renewable energy, capital formation, and economic growth on CO_2 emissions in the economies that are emerging due to China's Silk Road Economic Belt (SREB) initiative. The results suggested

that using a high share of renewable energy to execute economic activities and improve the level of capital formation significantly decreases the rate of CO_2 emissions in both the long term and short term in the considered SREB countries. Asongu and Odhiambo [23] showed that for low and middle-income countries, higher income inequality is linked with lower carbon dioxide (CO_2) emissions. Using a sample of 39 sub-Saharan countries consisting of lower- and middle-income countries, they investigated how increasing inequality affects renewable energy consumption. The empirical evidence is based on quadratic Tobit regressions. It was difficult to establish whether the inequality or equality hypothesis underpinning the nexus between income inequality and renewable energy consumption hold for Sub-Saharan Africa. Chen, Pinar, and Stengos [24] examined the causal link between renewable energy use and economic growth by employing a threshold model using a 103-country sample in the 1995 to 2015 period. They found that the relationship between renewable energy consumption and economic growth depends on the amount of renewable energy used. Wang and Wang [13] studied the relationship between renewable energy and economic growth focuses on the linear relationship, whereas ignoring the non-linear relationship. They found that the effect of renewable energy consumption on economic growth is positive, which indicates that increased renewable energy consumption contributes to economic growth.

Based on adopted a co-integration approach of asymmetric Autoregressive Distributed Lag (ARDL), Naseem, Ji, and Kashif [25] examined the asymmetrical effect of agriculture, energy consumption, and food security on carbon emission of Pakistan from 1970 to 2019. Our outcome endorses the existence of the asymmetrical effect of agriculture on CO_2 in the short- and long-term. Furthermore, the results of population and energy consumption increase environmental degradation. Nguyen and Vo [26] focused on examining gasoline demand elasticities in Australia. The short-run and long-run elasticities are estimated based on the panel data from seven capital cities in Australia between 2010 (quarter 3) and 2017 (quarter 4). The research results indicate short-run and long-run price elasticities of -0.11 and around -0.16 to -0.18, respectively. Although the conclusion is not able to be drawn about the long-run income elasticity of gasoline demand, the short-run finding of 1.35 shows that gasoline demand is income elastic. Zhunussova *et al.*, [27] studied the state of renewable energy development in Kazakhstan based on SWOT-analysis. The research results indicated that the driver of renewable energy development was the strategic planning of indicators; established regulatory and legal framework and open energy policy; the potential of RES resources; national production of solar cells; grants for full financing of research and development and partial financing of technology and equipment transfer for RES; consultations of foreign and domestic experts and specialists.

Taking evidence from the West Africa region, the relationship between renewable energy consumption and economic growth has been giving less attention, which is a significant gap given the high demand for energy consumption in that region. It may be noted that most of the studies are concentrated on developed and emerging countries. Also, those countries do not face serious energy crises such as power shortages, recurrent blackouts, and a low percentage of the population with access to electricity.

3. MATERIAL AND METHOD

3.1 Data Description

For this study, the set of fifteen West African countries (Benin, Burkina-Faso, Cape Verde, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory-Coast, Liberia Mali, Niger, Nigeria, Senegal, Sierra-Leone, and Togo) was used.

This study used annual data collected from sources such as World Bank's Sustainable Energy for All (SE4ALL); International Energy Agency, OECD database, and ECOWAS Report from 2000 to 2018 [3], [28]-[30].

3.2 Methodology

This study estimates the ARDL model that refers to a model with lags of both dependent and independent variables. This is a linear times model in which dependent and explanatory variables are related not contemporaneously but across historical values as well. The empirical model in this study is structured as follow:

$$\ln RGDP_t = \beta_0 + \beta_1 \ln L_t + \beta_2 \ln K_t + \beta_3 \ln REC_t + \beta_4 \ln AC_t + \beta_5 \ln GF_t + \varepsilon_t \quad (1)$$

Where the multivariate framework includes RGDP as real gross domestic product, L is labor force participation rate, K is capital, REC as the percentage of renewable energy consumption among total final energy consumption, AC as the percentage of the population with access to electricity, GF is gross fixed capital formation, β_0 is the intercept, β_1 to β_5 are the elasticities and et ε_t is the error term. The subscript t stands for the period-time.

The Autoregressive Distributed Lag (ARDL-Bounds) testing approach is used to observe short-run and long-run relationships among the series. The ARDL approach is advantageous to analyze variables with mixtures of the level of integration (I (0) or I (1)) than other techniques require the same level of integration and provide very efficient and consistent test results.

$$\Delta \ln RGDP_t = \beta_0 + \beta_1 + \sum_{i=1}^{p} \beta_i \Delta \ln L_{t-i} + \sum_{j=0}^{q} \beta_j \Delta \ln K_{t-j} + \sum_{k=0}^{r} \beta_k \Delta \ln REC_{t-k} + \sum_{l=0}^{s} \beta_l \Delta \ln AC_{t-l} + \sum_{m=0}^{t} \beta_m AC_{t-m} + \sum_{n=0}^{u} \beta_n GF_{t-n} + \phi_1 \ln RGDP_{t-1} + \phi_2 \ln L_{t-1} + \phi_3 \ln K_{t-1} + \phi_4 \ln REC_{t-1} + \phi_5 \ln AC_{t-1} + \phi_6 \ln GF_{t-1} + \varepsilon_t \quad (2)$$

The short-run and long-run among variables are tested by F-test where the joint significance of the coefficients of lagged variables is checked. The absence of a long-run relationship between the variables is $(H_0 : \phi_1 = \phi_2 = \phi_3 = \phi_4 = \phi_5 = \phi_6 = 0)$.

Based on the idea of Pesaran *et al.* [9] the existence of a long-run relationship among variables is proved by the rejection of Ho if F-value > upper bound if F-value < lower bound the Ho is held which means the non-long run relationship among variables while F-value≥ lower bound and ≤ upper bound, then the decision is inconclusive. Once the cointegration among variables is confirmed the step forward is the estimation of short-run and long-run relationships.

3.3 Estimation of the Short-run and Long-run Models

The vector error correction modeling of Granger (1988) is used to verify the direction of causality since the ARDL cointegration technique serves only for testing the existence or absence of short-run and long-run relationships among dependent and independent variables. The error correction models are estimated based on residuals of a long-run model in Equation (1). Therefore, Equation (2) was used to test the direction of causality among variables:

$$\Delta \ln RGDP_t = \beta_0 + \beta_1 + \sum_{i=1}^{p} \beta_i \Delta \ln L_{t-i} + \sum_{j=0}^{q} \beta_j \Delta \ln K_{t-j} + \sum_{k=0}^{r} \beta_k \Delta \ln REC_{t-k} + \sum_{l=0}^{s} \beta_l \Delta \ln AC_{t-l} + \sum_{m=0}^{t} \beta_m AC_{t-m} + \sum_{n=0}^{u} \beta_n GF_{t-n} + \phi_1 \ln RGDP_{t-1} + \phi_2 \ln L_{t-1} + \phi_3 \ln K_{t-1} + \phi_4 \ln REC_{t-1} + \phi_5 \ln AC_{t-1} + \phi_6 \ln GF_{t-1} + \lambda_1 ECT_{t-1} + \varepsilon_{1t} \quad (3)$$

The white noise term ε_{1t} is autonomously and normally distributed with zero mean and constant variance. The null hypothesis rejection shows the meaningful impact of independent variables on the dependent variable. Also, to fully study the causation and direction of causality among variables the conventional Granger causality method of Engle and Granger needed to be supplemented by the error-correction-based causality test [31], [32]. The conventional Granger causality method based on VAR and vector error-correction based, both test the directions for short-run and long-run Granger causality among variables including the error correction term. The error-correction-based causality test is performed based on results from the cointegration equation. The lagged correction terms are included to recapture the long-run information slacked through the differencing process.

Using Equation (3), the Granger causality can check the short-run or weak Granger causalities that were considered as the response of dependent variable to the short term shocks to the stochastic environment [33]. Causalities are noticed by testing $H_0 = \phi_1 = 0$, $H_0 = \phi_2 = 0$, $H_0 = \phi_3 = 0$, $H_0 = \phi_4 = 0$, $H_0 = \phi_5 = 0$, $H_0 = \phi_6 = 0$ in the Equation (3). Based on the idea of Masih and Masih [34] the statistical significance of the error correction term's coefficients in VECM's equations proves another feasible source of causality among variables which is qualified as the long-run relationship. The adjustment coefficient λ shows how fast disequilibrium from the long-run equilibrium is fixed due to the adjustment in every variable. By testing $H_0 = \lambda_1 = 0$; the long-run causalities are checked.

The fact that error correction terms' coefficients are at the moment significant, implies the presence of long-run causality among variables. Based on the idea of causality proposed by Asafu-Adjaye [33], if RGDP, L, K, REC, AC, and GF are cointegrated, this implies the presence of non-null significant values for one or all right-hand terms. In addition to this, each dependent variable in every equation for VECM's equations should be ready to respond to the change of its lagged value and this type of causation indicate which variable needs the short-run adjustment in the cost of the long-run equilibrium. Once the hypothetical causal link is valid in the VECM equations, all independent variables are reported as good determinants of the dependent variable.

4. RESULTS AND DISCUSSION

4.1 Unit Root Test for Time Series

Table 1 presents an analysis of the descriptive statistics of the variables employed in the study. The mean, median, and other essential characteristics of the variables employed are reported in Table 1. The descriptive statistics are presented for real gross domestic product, labor force participation rate, capital, the percentage of renewable energy consumption among total final energy consumption, the percentage of the population with access to electricity, and gross fixed capital formation. Table 1 presents the descriptive statistics of the variables.

The study tests for the stationarity or otherwise of the variables employed. First, we applied two conventional unit root tests, namely Augmented Dickey-Fuller (1979) and Phillips and Perron (1988) to test the null hypothesis of a unit root. Both the ADF and PP tests do not take into account the possibility of structural breaks. Therefore, they may lead to a misleading result when accepting the null hypothesis of a unit root.

Second, the Zivot-Andrews and Perron unit root tests are utilized. The structural change is of considerable importance in the analysis of macroeconomic time series. An associated problem is the testing of the null hypothesis of structural stability against the alternative of a one-time structural break. If such structural changes are present in the data generating process, but not allowed for in the specification of an econometric model, results may be biased towards the erroneous non-rejection of the non-stationarity hypothesis. The lag length is chosen by AIC.

Based on Table 2 and Table 3, the results from Zivot-Andrews and Perron tests suggest that RGDP, REC, K, and AC series are I (1); however, L and GF are I(0). The Zivot-Andrews and Perron unit root tests found different dates of structural breaks. However, this is consistent with some previous empirical results. The structural breaks which took place between 2008 and 2012 refer to the period of the global economic crisis as well as west African countries' renewable energies policies implementation. Due to the higher rate of foreign investment, West African countries made major structural changes in the economy. Most of the West African countries rely on foreign direct investment for public and private sector development. In the mid 2011, West African countries have adopted the Renewable Energy Policy (REP) intending to increase the share of renewable energies in the global electricity mix. West African countries indicated that new investment in electricity production should be generated by local and renewable resources.

Table 1. Descriptive statistics.

Variables	Mean	Maximum	Minimum	Std. Dev
RGDP	4.484	20.715	-15.145	4.071
REC	70.55	91.513	21.620	18.279
L	64.621	89.1	26.49	12.495
K	9.065	231.41	-53.982	26.424
AC	33.632	90.645	1.834	21.192
GF	19.129	46.732	1.096	8.560

Table 2. Zivot-Andrews unit root test results.

Variables	At level	Break date	At First Difference	Break date
lnRGDP	-5.033(2)	2008	-6.383(0)***	2009
lnL	-4.821(2)***	2009	-5.587(0)***	2010
lnK	-3.921(0)	2008	-4.967(0)***	2006
lnREC	-5.875(0)	2010	-7.520(0)***	2012
lnGF	-4.613(2)**	2008	-5.861(0)***	2010
lnAC	-3.114(0)	2009	-6.024(0)***	2012

, ** and * indicates respectively rejection of the null hypothesis of unit root at 10%, 5%, and 1% significant level*

Table 3.Perron unit root test results.

Variables	At level	Break date	At First Difference	Break date
lnRGDP	-5.453(0)	2009	-6.572(0)***	2008
lnL	-4.579(0)***	2010	-7.287(0)***	2008
lnK	-3.986(0)	2007	-5.561(0)***	2010
lnREC	-5.796(0)	2008	-6.719(0)***	2013
lnGF	-4.176(0)***	2009	-7.341(0)***	2011
lnAC	-4.032(0)	2010	-6.104(0)***	2012

*, ** and *** indicates respectively rejection of the null hypothesis of unit root at 10%, 5%, and 1% significant level

Table 4. ARDL test result.

Estimated equation	lnRGDP =f(lnL, , lnREC, lnAC,)	
Test Statistic	Value	
F-statistic	6.352	
Critical value bounds		
Significance	Lower bound(I0)	Upper Bound (I1)
10%	2.68	3.79
5%	3.34	4.32
2.5%	3.86	4.85
1%	4.17	5.67

4.2 ARDL Bound Test Approach Analysis

The results of the ARDL according to Table 4, the consolidated test for the cointegration test reveals that there is a long-run relationship between real gross domestic product (RGDP), capital (K), renewable energy consumption (REC), and percentage of access to electricity (AC) at 5 percent level of significance. It is evident that the calculated F-statistic of 6.352 is greater than the upper bound critical value of 5.67; therefore the null hypothesis of no cointegration is rejected even below at 1% level of significance which testifies the presence of a long-run relationship between RGDP and all explanatory variables for this paper.

4.3 Cointegration Results

The results of the Zivot-Andrews and Perron unit root tests suggest that we should proceed in our analysis only with variables that are from order one, RGDP, REC, K, and AC. Consequently, we should drop the labor force participation rate and gross fixed capital formation from the cointegration and causality analysis. The ARDL Bound test approach tests the short-run and long-run relationship. The findings of the ADRL cointegration have confirmed in the short run that renewable energy consumption has an insignificant impact on economic growth. The long-run analysis displayed in Table 5 indicated that both variables have a significant and positive impact on economic growth. Also, the adjustment coefficient proves the existence of a long-run relationship between the variables. The disequilibrium is restored at a rate of 25.2%. In short-run, the negative sign of renewable energy consumption suggests that an increase by 1% in renewable energy consumption could decrease RGDP by about 0.10%. The negative effect can be attributed to the early stages of the development of renewable energy and most of those countries still rely on non-renewable energy. Biomass is used mainly by households for cooking and constitutes in West Africa. Household cooking could have both an indirect impact on growth as cooking provides food that serves as a source of energy for labor and enables labor to do more work. However, there is no established direct link between household cooking and growth. Based on the long-run result, an increase of 1% in renewable energy consumption could increase RGDP by about 0.14%.

Table 5. Short-run and long-run results.

Long-run relationship among variables				
Variables	Coefficient	Std. Error	t-Statistic	Prob.
lnK	0.276	0.119	2.322	0.026
lnREC	0.149	0.087	1.046	0.067
lnAC	0.086	0.220	0.390	0.069
C	5.903	0.714	8.261	0.002
Short run relationship among variables				
CointEq(-1)	-0.252	0.072	-3.497	0.001
Δ(lnK)	0.076	0.119	2.322	0.026
Δ(lnREC)	-0.102	0.022	-1.124	0.307
Δ(lnAC)	0.157	0.064	2.466	0.018
R^2=0.68				
F-statistic=13.207				
Prob.(F-statistic)= 0.0000				

4.4 Causality Results

The vector error correction model-based Granger causality is employed in investigating the short-run and long-run dynamics of the variables. Results from the short-run and long-run granger causality test are consistent with the short-run and long-run vector error correction model estimates. The ARDL-approach occurrence relationships indicate that there must be one or two ways to cause Granger causality among the proposed variables. Granger causality based on the vector error correction model includes three types of Granger causality according to the Wald test: short-run (low), long-run, and strong Granger causality. The results of Granger causality among the RGDP and REC are presented in Table 6.

Table 6. Granger causality results.

Null hypotheses	F-Statistics	Probability	Conclusion on causality
Short-run(weak) Granger Causality by Wald-Test			
DRGDP→ DREC	0.187	0.676	The economic growth doesn't prove weak Granger causality to REC.
DREC → DRGDP	0.348	0.623	REC has no weak Granger causality to RGDP.
Long run Granger Causality by Wald-Test			
ECT→DGDP Ho: $\lambda_{=}0$	3.382*	0.064	In Equation (3), the adjustment coefficient proves the long-run Granger causality which means that RGDP does react to the disequilibrium from the long-run equilibrium in the previous period.
Strong Granger Causality by Wald-Test			
Summary of strong causality in Equation (3) DK,DREC,DAC →DGDP Ho: $\phi_{1j} = \phi_{1k} = \phi_{1l} = \phi_{1m} = \lambda = 0$	4.457***	0.001	All independent variables revealed a strong Granger causality to the economic growth which means that they are the best determinants of economic growth for this case study.
DRGDP, ECT→DREC Ho: $\phi_{1i=}\ \lambda_{=0}$	0.097	0.925	Here RGDP appears with no strong Granger causality to REC.
DREC, ECT→DRGDP Ho: $\phi_{1k} = \lambda_1 = 0$	6.436***	0.001	There is the presence of strong Granger causality from REC to RGDP

The results of VECM Granger causality are interpreted based on Granger causality short-run and long-run Granger causality. Our findings show all independent variables revealed a strong Granger causality to the economic growth which means that they are important determinants of economic growth for this study. So this means that capital, the percentage of renewable energy consumption among total final energy consumption, and the percentage of the population with access to electricity decrease could probably restrain the economic development.

From Table 6, there is no short-run causal relationship running from renewable energy consumption to economic growth. More so, there is no causal relationship running from GDP to renewable energy consumption. The results show that the coefficient for renewable energy consumption is highly insignificant statistically and for that matter, renewable energy consumption has no influence on economic growth in the short run. This finding is also confirmed by [35], [36]. Nondo [35] explored the link between energy consumption and growth using a panel of nineteen African countries found the coefficients for energy consumption and GDP to be insignificant in the short run. Therefore, they concluded that in the short run, there is no causality running from energy consumption to GDP or from GDP to energy consumption. A plausible explanation for the existence of the neutrality hypothesis running from energy consumption to GDP is due to the energy consumption mix in the sub-region.In long-run, the findings indicated the presence of at least one direction of high Granger causality. The result indicated that the renewable energy consumption differential positively leads to an increase in economic growth. In regards to Equation (3), the adjustment coefficient proves the long-run Granger causality which means that real gross domestic product does react to the disequilibrium from the long-run equilibrium in the previous period. The findings indicated that in the long-run there is a unidirectional causality running from renewable energy consumption to economic growth. A plausible explanation why renewable energy consumption has a statistically significant and positive relationship with economic growth as reported in Table 6 and therefore a causal relationship running from REC to RGDP as shown in Table 5 is that as renewable energy increase primary energy supply which improves the living standards for individual and improves the industrial production. Stated differently, individuals are able to increase their

consumption of electricity through the use of technology as income increases. Further, as the energy consumption grows, the economic environment becomes generally good for business; investors are attracted into the country to establish industries which tend to increase electricity requirements and offer new job opportunity for the local population.

The result from Table 7summarized the diagnostic test results. Residue diagnostic tests and stability tests were performed to avoid errors in model specification. The results of the diagnostic tests revealed the high stability and consistency of the model parameters, which are based on the 5% curve of the critical link defined by CUSUM proposed by Brown *et al.* (1975). The test revealed the absence of serial correlation until the 2nd shift with an F statistic of 0.908 and a probability of 0.412 greater than a 10% level of significance. The model is homoscedastic under Breusch-Pagan-Godfrey with an F statistic of 0.759 with a probability of 0.558, which is greater than a 10% level of significance. The residues were found normally distributed according to the Jarque-Bera normality test of 1.048 with a probability of 0.592. The Wald test confirmed that the coefficients of the independent variables jointly affect the dependent variable with an F statistic of 9.503 and a probability of 0.0004.

Table 7. Diagnostic tests results.

	F statistic	Probability
CUSUM	0.908	0.412
Breusch-Pagan-Godfrey	0.759	0.558
Jarque-Bera	1.048	0.592
Wald test	9.503	0.004

5. CONCLUSION

This paper investigates the short-run and long-run relationship between renewable energy consumption and economic growth from 2000 to 2018. The study focused on West Africa due to the dearth of studies available on renewable energy consumption and growth in the region. The dynamic relationship between our variables (real gross domestic product, labor force participation rate, capital, the percentage of renewable energy consumption among total final energy consumption, the percentage of the population with access to electricity, and gross fixed capital formation) was examined using the Autoregressive Distributed Lag- Bounds test approach and vector error correction model. The results show in the short-run renewable energy consumption has an insignificant and negative effect on economic growth; while in the long-run has a significant and positive effect on economic growth. It is also revealed that in the short-run there is no causality running between economic growth and renewable energy consumption. This could be due to fact that biomass is used mainly by households for cooking in West Africa as well as the early stages of the development of renewable energy. However, in the long-run, there is a unidirectional causality running from renewable energy consumption to economic growth. Given the number of national and regional REP adopted each year. The results obtained were consistent with the theoretical and empirical findings of previous studies.

This study delves into the West African countries' energy sector suggesting that renewable energy can promote economic growth in the long-run. In that direction, it's necessary to promote the use of renewable energy sources for small networks or off-grid solutions, which constitute a great alternative for renewable energy consumption and electricity access for rural areas population. Renewable energy resources are important factors in setting an ambitious path for the renewable energy sector at a regional level. They are key mechanisms to promote the growth of renewable energy in a long-term perspective. In light of the results documented in this study, it is important to implement measures that will ensure increased access to electricity is effectively pursued in the West African sub-region. It is however important to accentuate the fact that the region currently has policies or projects aimed at increasing the generation capacity of electricity in the sub-region as well as policies to increase access to electricity. These regional approaches to increasing access to energy in the sub-region are essential as they allow for the pooling of resources by member countries and thereby resulting in a relatively lower cost incurred compared to the cost the individual countries may have incurred. Again, some countries that are less endowed in some natural resources can benefit from the resources of other countries through the regional approach to satisfying the energy demands of the sub-region. The study, therefore, recommends a regional approach to solving the energy problems in West Africa. Also, it is important to accentuate the fact that in some instances, it would be more economical to adopt a country-level approach to providing solutions in the energy sector due to peculiar scenarios that may be existent in particular countries.

In West Africa, it is important to implement measures that would reduce the use of traditional biomass are executed. Traditional biomass constitutes a significant proportion of energy consumed in the sub-region. This has encouraged deforestation, land degradation which is making it difficult for the sub-region to mitigate the impact of climate change. Again, the burning of wood, charcoal has undesirable effects on the health of individuals in the sub-region. The use of LPG gas should be encouraged to reduce the use of firewood in cooking. The use of modern biomass should also be encouraged in the sub-region. In that direction, West African countries need to develop profitable projects on renewable energy that can attract investors and financial institutions. Also, they need to develop framework coherence between the national and regional renewable energy policies to ensure an effective institutional regulatory framework.

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