Dynamic Relation between Sustainable Development and Renewable Energy Consumption: Evidence from ECOWAS Region

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Abstract. This paper studies Economic Community of West African States (ECOWAS) economic growth and renewable energy consumption (REC) dynamic relation over the period of 2002 to 2016. This study conducts an empirical analysis using Autoregressive Distributed Lag- Bounds approach (ARDL) and VECM based on Granger causality. The results show that renewable energy consumption has significant and positive impact on economic growth; also show unidirectional Granger Causality from renewable energy consumption and the percentage of electricity access to economic growth. In addition, findings indicate bidirectional Granger causality between economic growth and carbon dioxide emission. Moreover our findings indicate that REC increase by 1 per cent leads to 0.009 increases in Real GDP in long run. Therefore, REC can play an important role to ensure sustainable development in the ECOWAS. However, further investments and policies to promote renewable energy consumption are required to enhance sustainable development the region.

1. Introduction

In today’s societies renewable energy plays an important part to economic progress; access to renewable energy is a major factor for sustainability in developed and developing countries. There has been a steady shift from traditional sources of energy to renewable energy in recent decades [1]. Due to the fact that traditional forms of energy production has negative effects on environment, so the use of renewable energy sources is urgent [2]. Climate change issues arose as a result of greenhouse gas emissions from fossil fuel combustion. A longer dependence of fossil fuel aims to cope with a growing energy demand which can accelerate the degradation of the environment [3-5]. Contemporary economic well-being is compromised by circumstances such as the increase in energy demand and consumption caused by the increase of the world's population. In fact, lack of access to electricity indicates a poor situation in terms of poverty reduction and accelerated development. Therefore, the development strategies describe the renewable energy as the fundamental key to achieve sustainable development. Sustainable development is based on three pillars: economic, social and environmental and the flow of resource use and the value of externalities created [6, 7]. The ECOWAS region in the western sub-region of Africa made up of fifteen (15) Member States with more than 335 million inhabitants in 2018 is determined to create an environment for clean and modern energy production. A modern and efficient energy system provides better services, allowing country economy to thrive and reduce the level of pollution. Thus, in recent decades, many developing countries particularly those in West Africa have adopted development strategies that prioritize the modernization of their energy
systems. These strategies attempt to resolve severe energy crisis and to develop appropriate regulatory frameworks for the RE use and strengthen regional integration in the energy sector. These strategies also promote the use of renewable sources through the reduction of traditional energies use such as wood. In addition, many of ECOWAS Member States experienced high economic growth between 2012 and 2015.

Taking evidence from ECOWAS region, this paper studies the dynamic relation between economic growth and renewable energy consumption, and how they interact over time in ECOWAS region. Specifically, the objective is to investigate that relationship in long-run. This objective is pursued through an empirical analysis using in the first the Autoregressive Distributed Lag- Bounds test approach (ARDL). The ADRL is applied as advantageous technique to analyze variables with mixtures of level of integration I (0) or I (1)) than other techniques that require the same level of integration and provides very efficient and consistent results in small and large sample sizes [8]. This paper uses West African sub-regional economic aspect to check the dynamic relation between selected variables. The second line of researches combines the approaches of the above-discussed streams on the linkages among REC, COE, AC and RGDP. Vector Error Correction Model (VECM) approach is used to study the dynamic linkages among the selected variables. Most of existing researches on sustainable development often focus on the impact on the environment. Nevertheless, less attention has been paid to the influence of renewable energy consumption, which is a significant gap given the high demand of energy consumption in the world.

2. Methodology
The empirical model in this study is structured as follow:

\[ LRGDP_t = \alpha + \gamma LREC_t + \Psi LCOE_t + \pi LAC_t + \epsilon_t \quad (1) \]

In this study framework includes RGDP (real gross domestic product) as dependent variable; for independent variables includes REC (renewable energy consumption percentage of total final energy consumption), COE (carbon dioxide emissions metric tons per capita), AC( percentage of population for electricity access) and \( \gamma, \Psi, \pi = \) coefficients of independent variables, \( \alpha = \) constant, \( L = \) logarithm, \( \epsilon = \) error term.

After ARDL bounds test introduced by Pesaran et al. [8] is used. The model is arranged as follow:

\[
\Delta LRGDP_t = \alpha_1 + \sum_{i=1}^{p_1} \beta_i \Delta LRGDP_{t-i} + \sum_{j=0}^{q_1} \gamma_j \Delta LREC_{t-j} - \sum_{k=0}^{r_1} \Psi_k \Delta LCOE_{t-k} - \sum_{l=0}^{s_1} \pi_l \Delta LAC_{3l} - i + \psi_4 LRGDP_{t-1} + \psi_5 LREC_{t-1} + \psi_6 LCOE_{t-1} + \psi_7 LAC_{t-1} + \epsilon_t \quad (2)
\]

The long run among variables is tested by F-test where the coefficients of lagged variables are checked. In long-run the absence of relationship between the variables is (Ho: \( \psi 4 = \psi 5 = \psi 6 = \psi 7 = 0 \)).

3. Analysis and Results

3.1. The Analysis of ARDL Bound Test Approach
ARDL bound approach is used to verify long run dynamic relation between RGDP and REC in ECOWAS Member States (table 1). In this study, we started with the stationary test. Our results confirmed that all selected variables are stationary at level with significance at 1% except LREC which is stationary at first difference which gives the signal of necessity of bounds test approach to find whether exist or not of the long run relationships among selected variables. The cointegration test findings show that at 5 percent level of significance there is long run relationship between RGDP, REC, COE and AC. Our findings indicates that calculated value of F-statistic (6.121) is greater than the critical value of upper bound (5.61); so at 1% level of significance the null hypothesis of no
cointegration is rejected. Therefore, our findings show the presence of long run relationship between RGDP and others selected variables for this paper.

Table 1. ARDL results.

| Variables | Coef. | Std. Err | t-Statistic | Prob. |
|-----------|-------|----------|-------------|-------|
| LRECt     | 0.009 | 0.089    | 0.104       | 0.917 |
| LCOEt     | 0.276 | 0.119    | 2.322       | 0.026 |
| LACt      | 0.086 | 0.220    | 0.390       | 0.698 |
| C         | 5.903 | 0.714    | 8.261       | 0.000 |

3.2. Causality Results

In this section, Granger causality based on the VECM includes two types of Granger causality according to the Wald test: long-run and strong Granger causality. Table 2 shows the output of Granger causality among the proposed variables.

The results of table 2 are interpreted on the basis of high Granger causality 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 best determinants of economic growth for this study. First renewable energy consumption and percentage of electricity access revealed a strong unidirectional to real gross domestic product, except for carbon dioxide emissions which exhibited a strong bidirectional to real gross domestic product. This means that economic growth is dependent of renewable energy consumption and the percentage of electricity access, and a decrease in renewable energy consumption and the percentage of electricity access could probably impact the development economic. Secondly, the presence of at least one direction of high Granger causality means that all independent variables are the best determinants of economic growth in ECOWAS. Renewable energy consumption unidirectional Granger causal to carbon dioxide emissions and percentage of electricity access unidirectional Granger strong cause to carbon dioxide emissions unified Granger causalities to carbon dioxide emissions. Thirdly, the causal relation from percentage of access to electricity to carbon dioxide emissions is very important because increase in access to electricity will highly impact on carbon dioxide emissions, with no other significant positive impact on economic growth.

4. Conclusion

Based on the previous studies, this paper studies the dynamic relation between economy growth and renewable energy consumption over the period 2002-2016 of ECOWAS countries. For the empirical analysis, ADRL and VCEM granger causality are combined. We use panel data of ECOWAS countries. Several empirical findings have been provided. The empirical results confirm a statistically significant and positive relationship between economic growth and renewable energy consumption in the long run. Based on the VCEM Granger causality results carbon dioxide emissions has bidirectional stronger Granger causality to economic growth. Renewable energy consumption and percentage of electricity access present unidirectional strong Granger causality to economic growth. Though, ECOWAS region repeatedly suffer from energy supply inefficiencies, power shortages and recurrent blackouts, which have impacted their socioeconomic development. From our findings renewable energy consumption can play an important role to achieve future sustainable development in ECOWAS. The implementations of different policies in their energy sectors are necessary to boost energy supply efficiency and percentage of access to electricity.

Through our findings to achieve sustainable economic growth, the ECOWAS countries should revolve to promote the use of renewable energy and to develop regional regulatory framework. Furthermore ECOWAS Member States commitment is necessary to achieve energy supply efficiency, security and sustainable development throughout the region. Hence, more studies into the region energy sectors are necessary to provide further evidence.
Table 2. Granger Causality based on VECM.

| Null hypotheses | F-Statistics | Probability | Conclusion on causality |
|-----------------|-------------|-------------|-------------------------|
| DREC,ECT→DRGDP Ho: $\gamma_{4j} = \omega_1 = 0$ | 6.466*** | 0.001 | There is the presence of strong Granger causality of REC to GDP |
| DCOE,ECT→DRGDP Ho: $\Psi_{4k} = \omega_1 = 0$ | 3.510** | 0.029 | Presence of strong Granger causality of COE to GDP |
| DAC,ECT→DRGDP Ho: $\pi_{4l} = \omega_1 = 0$ | 2.722* | 0.065 | Presence of strong Granger causality of AC to GDP |
| Summary of strong causality in Eq(2) DREC,DCOE,DAC→DRGDP Ho: $\gamma_{4j} = \Psi_{4k} = \pi_{4l} = \omega_1 = 0$ | 4.457*** | 0.001 | All independent variables revealed a strong Granger causality to the economic growth which means that they are best determinants of economic growth for this case study. |
| DRGDP,ECT→DREC Ho: $\beta_{5i} = \omega_2 = 0$ | 0.092 | 0.912 | GDP appears with no strong Granger causality to REC. |
| DCOE,ECT→DREC Ho: $\Psi_{5k} = \omega_2 = 0$ | 0.570 | 0.565 | No presence strong Granger causality between COE and REC. |
| DAC,ECT→ DREC Ho: $\pi_{5l} = \omega_2 = 0$ | 4.354** | 0.012 | AC strong Granger causality to REC. |
| DRGDP,ECT→DCOE Ho: $\beta_{6i} = \omega_3 = 0$ | 11.201*** | 0.000 | GDP has strong Granger causality COE |
| DREC,ECT→ DCOE Ho: $\gamma_{6j} = \omega_2 = 0$ | 6.4318*** | 0.001 | Presence of strong Granger causality between REC and COE. |
| DAC,ECT→ DCOE Ho: $\pi_{6l} = \omega_3 = 0$ | 4.758** | 0.008 | AC is strongly Granger cause increase of COE |
| DRGDP,ECT→DAC Ho: $\beta_{7i} = \omega_4 = 0$ | 0.813 | 0.443 | No strong Granger causality from RGDP to AC |
| DREC,ECT→ DAC Ho: $\gamma_{7j} = \omega_4 = 0$ | 0.696 | 0.498 | No strong Granger causality from REC to AC |
| DCOE,ECT→DAC Ho: $\Psi_{7k} = \omega_4 = 0$ | 1.003 | 0.366 | COE do not have strong Granger causality to AC |

Note: ***, **, * are respectively 1%, 5% and 10% significance levels.

References
[1] Rodríguez-Monroy C, Mármol-Acitores G and Nilsson-Cifuentes G 2018 Electricity generation in Chile using non-conventional renewable energy sources–A focus on biomass Renewable and Sustainable Energy Reviews 81 937-945.
[2] Papageorgiou C, Saam M and Schulte P 2017 Substitution between clean and dirty energy inputs: A macroeconomic perspective Review of Economics and Statistics 99 281-290.
[3] Sebri M 2015 Use renewables to be cleaner: meta-analysis of the renewable energy consumption–economic growth nexus Renewable and Sustainable Energy Reviews 42 657-665.

[4] Terrapon-Pfaff J, Dienst C, König J and Ortiz W 2014 A cross-sectional review: Impacts and sustainability of small-scale renewable energy projects in developing countries Renewable and Sustainable Energy Reviews 40 1-10.

[5] Gottschamer L and Zhang Q 2016 Interactions of factors impacting implementation and sustainability of renewable energy sourced electricity Renewable and Sustainable Energy Reviews 65 164-174.

[6] Beça P and Santos R 2010 Measuring sustainable welfare: A new approach to the ISEW, Ecological Economics 69 810-819.

[7] Moldan B, Janoušková S and Hák T 2012 How to understand and measure environmental sustainability: Indicators and targets Ecological Indicators 17 4-13.

[8] Pesaran M H, Shin Y and Smith R J 2001 Bounds testing approaches to the analysis of level relationships Journal of Applied Econometrics 16 289-326.