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Determinants of Renewable Energy Consumption in Nigeria: A Toda Yamamoto Approach

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Determinants of Renewable Energy Consumption in Nigeria: A Toda Yamamoto Approach

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Abstract: Nigeria has inadequate power supply and this issue has lingered for years despite power sector reforms. Renewable resources could to be offering sustainable alternative energy supply in rural and urban regions of Nigeria. So, the key factors that determine the utilization of renewable energy in Nigeria are estimated in this paper for a period of twenty-four years using toda yamamoto method. Long-run relationship exists between renewable energy consumption and its determinants in Nigeria. Real income (real GDP) and emissions of CO2 are the most significant determinants of oil products import demand in Nigeria. Trade Openness was found to be insignificant. The analysis showed no causality between the consumption of renewable energy and some of its determinants. However, unidirectional causality runs from CO2 emission to GDP which implies that fossil fuels are significant drivers of real GDP or economic growth for Nigeria. It is evidenced that environmental considerations are less critical than real income to the consumption and development of renewable energy in Nigeria. Policy-makers should proffer incentives and measures that incentivize increased production and consumption of renewable energy while driving macroeconomic stability – especially in post COVID-19 era.

Keywords: Renewable Energy Consumption, Toda Yamamoto; CO_2 Emissions, Trade Openness

1.0   INTRODUCTION

There are great prospects for renewable energy resources as input into the future production revolution. They are clean, abundant, sustainable and evenly distributed - most nations and regions have renewable energy resources. The economic implication is that no nation on earth has an absolute advantage over another regarding renewable energy resources [1]. Historically, one key challenge to the exploitation and consumption of renewable energy resources is high cost of the technologies relative to fossil fuels [2]. Fossil fuels are environmentally hazardous, non-renewable and have become unsustainable.

Energy consumption is always associated with industrialization and economic growth, but until recently renewable energy consumption did not constitute significantly to global increase in energy demand. The 1973 oil market crisis exposed the geopolitical implications of relying on unevenly distributed fossil-based energy resources in the quest for economic development [3]. This evidently led to calls towards diversification of energy sources which obviously included renewables. Statistical data show increased renewable energy resources in the global energy mix – especially in net oil importing countries - due to environmental considerations, strong political support, and high demand [4]; [5]. Meanwhile, other studies, [23]; [19]; as well as, [19] posited growth in the renewable energy industry will be driven by political problems, crude oil price volatility and environmental concerns, thereby bringing an end to the fossil fuel era. Furthermore, the 1992 United Nations Framework Convention on Climate Change conference of 1992 signaled the beginning of a new era where the world's energy mix and use took a radical turn such that renewable energy consumption would be given the utmost priority. That conference emphasized the environmental consequences of the world's growing emission levels and the resultant economic effects in form of externalities. The signing and ratification of the Paris Agreement (COP21) by most member countries of the UN marked a historic achievement in the evolution of the world's energy mix (favouring renewables) and the quest for sustainable development [4].

Nigeria's endowment of renewable energy resources is abundant – biomass, hydro, solar and wind – is abundant with geothermal and hydrogen potentials. In addition, renewable energy technologies offer possible solution to Nigeria's protracted energy problems because the renewable resources are sustainable and suitable for installation in mini-grids with communal ownership [32]. Exploiting renewable resources and adopting alternative technologies are means by which Nigeria could attain steady power supply and energy efficiency. Nigeria's federal government has reformed the electricity sector to attract private investors towards

increasing renewable energy supply. Notwithstanding, there are prevailing financial, technical, regulatory issues to be resolved [18]; [31].

The determinants of renewable energy consumption have been analyzed in various regions – some of which are reviewed in Section 2. [11] used autoregressive distributed lag (ARDL) bounds cointegration method to consider the issue in the Balkan countries. This relies on the same approach to empirically ascertain the drivers of renewable energy consumption in Nigeria. It adds to existing knowledge by analyzing the causal link between the variables of interest using Toda Yamamoto (TY) approach to Granger Causality. Literature review is presented in the second section of the paper with the key research problem considered in the study and some underlying facts. Section 3 describes the variables of interest, scope of the study, data source, scope and frequency, as well as, the methodology applied. In section 4, the results of the analysis are presented and discussed with the estimation procedure. It presents the empirical results for the preliminary analysis, main regression and diagnostics with their accompanying interpretations and policy implications. The paper ends in section 5 proffering some areas for further studies.

2.0 LITERATURE REVIEW

2.1 Literature Review

Renewable energy consumption has been analyzed with panel data and time series data in various studies – [9]; [12]; [10]; [30]; [14] - G7 countries (1980-2009); [27] - the US (2013-2055); as well as, [7] - panel data analysis for oil-producing African countries (1985-2010); and [22] – in Balkan countries. However, only a few studies have applied Toda Yamamoto approach to analyze the factors that determine the consumption of renewable energy in Nigeria. Using dynamic GMM panel approach, for the period 1990-2011, [25] evaluated the determinants of renewable energy consumption in sixty-four countries. The study evidenced that there is a statistically significant effect of trade openness on income groups apart from the highest income levels. Analyzing different income groups, the study revealed that renewable energy consumption also increases when both GDP and CO_2 increase. Carbon emissions is the transmission mechanism or pathway through which demand for cleaner environment creates more interest in renewable energy resources and alternative technologies. Meanwhile, oil price was found to affect renewable energy consumption also, though slightly. Hence, it is arguable that renewable energy is not a sufficient alternative to fossil fuel at least for now because despite 85.99Mt of emissions [21] petroleum products importations is increasing in Nigeria. For the period 1985-2010 and using panel data analytical approach, [7] evaluated the consumption of renewable energy in African oil-producing nations. The research outcome indicates that, in the countries considered, the determinants of renewable energy consumption are per capita CO_2 emission, per capita GDP, consumption of energy resources, and energy prices. But, renewable energy consumption has a negative relationship with energy prices and carbon emission – though statistically insignificant. From an empirical perspective, [24] compared the dynamic and static approaches of analyzing the drivers of renewable energy. The study shows that static panel data approach yields less efficient estimators than the dynamic model. In addition, it was revealed that changes in per capita renewable energy consumption are driven mainly by increases in international trade per capita and CO_2 emissions. Focusing on the Balkans, [11] used dynamic panel data to analyze the determinants of renewable energy consumption. On one hand, the result showed statistically significant and negative relationship between renewable energy consumption and economic growth. "*On the other hand, trade openness and natural gas rents have a positive effect on renewable energy consumption*" [11]

2.2 Key Issues regarding Nigeria

Few nations are richly endowed with energy resources essential for sustainable development and consequently net exporters of such resources for their benefit. The rest of the world has negligible amount – often constituting the net energy importers. Nigeria is a net importer of petroleum products despite abundant fossil fuel resources. Coal is one of the abundant hydrocarbons in Nigeria, but it is yet to be fully explored as an energy resource. Nigeria, having signed the Paris Climate Change Agreement, is expected to use clean technology in developing the available resources (including coal). Meanwhile, [8] posit an ambiguous link between economic growth and coal consumption. In the circumstances, renewable energy resources seem feasible complementary alternatives for enhancing the country's trade balance, growth and development.

Despite her abundant renewable energy resources, Nigeria depends on biomass and petroleum products to meet her energy needs. For instance, 96.3% of Nigeria's exports in 2016 was from crude oil with only a small fraction of this available for domestic use [29]. About 61% of households in Nigeria have access

to 26.26TWh of electricity but reliability is a major concern [21]. As such, most city dwellers and private firms supplement public power supply with diesel or petrol generating plants. Most companies and business incur high costs and emit greenhouse gas through the use of small and medium electricity generators [15]. Back-up power costs households and business in Nigeria about USD22Billion per annum in fuel cost alone [21]. Inadequate supply of energy is a major problem in Nigeria which is hindering her industrialization and sustainable economic development. In fact, finding permanent solutions to Nigeria's power problems has remained one of the priorities of all government administration in the last twenty years. So, dependence on fossil fuels alone is insufficient to meet Nigeria's future energy needs. This becomes detrimental to long term energy policy-making for the nation improve energy efficiency and attain sustainable energy. Are renewable resources and technologies considerable for achieving long-term energy solutions? Furthermore, the deplorable state of rural energy supply and consumption especially electricity amidst abundant renewable energy resources in Nigeria justifies the need for assessing the determinants. The logistic requirements and associated cost of supplying electricity to rural areas, as well as, the low income and purchasing power of the communities are disincentives to power generating and distribution companies. Therefore, it is pathetic that the energy needs of rural Nigerians have been mostly unsatisfied and the potentials for growth in so doing have remained largely untapped.

Primary energy sources are non-renewable and so their consumption is totally unsustainable. The declining levels of fossil fuel exploration and investments is of concern to Nigeria and, perhaps to other OPEC member-nations. Hence, the need to assess the factors that could drive a possible transition to renewable energy sources. Renewable alternatives are limitless, inexhaustible and reoccurring in stock. Furthermore, renewable energy sources are becoming more important in today's world due to their cleanness. Furthermore, countries using renewable energy sources will be reducing fossil fuels imports and, thereby be less susceptible to oil price volatility and related macroeconomic shocks. For such reasons, [13] have argued that all developing and developed countries should increase activities related to the consumption and production of renewable energy. Climate change, which is a consequence of greenhouse gas (GHG) emissions and environmental pollution inherent in the reliance on fossil fuel in pursuit of industrialization, has been identified as one of the biggest threats facing the existence of man in the 21st Century. The ratification of the Paris Climate Change agreement (COP21) by most nations of the world appears to have marked a turning point in the fight against environmental pollution and dominance of hydrocarbons in the world's energy mix. The agreement which aims to limit the rise in global temperature to a level below 2°C can only be achieved by lowering CO_2 emission by at least 20%. While this is positive news to renewable energy development initiatives, it comes with serious economic implications and challenges.

For developing countries, there is the technical challenge of simultaneously decarbonizing and growing their economy. The implication is that India and China that are major emitters of greenhouse gases will keenly pursue their Nationally Determined Contribution within their economic growth plans. Similarly, Nigeria as a developing country needs high energy consumption to grow especially in the face of her increasing population. However, the growing concerns over climate change and the quest for sustainable development appears to place a limit on the level of energy consumption that is tenable using fossil fuels. Therefore, this paper addresses the following questions:
- What factors determine the consumption of renewable energy in Nigeria?
- Is there a long run relationship between such determining factors and renewable energy consumption?
- What causal relationship exists amongst renewable energy consumption and its determinants?

The above questions are relevant and timely. A developing country, like Nigeria, seeking to industrialize is constrained to consider switching to cleaner and sustainable energy sources towards achieving future consumption and development goals. Moreover, Nigeria's intention to diversify away from crude oil-dependence further highlights the importance of address the research issues.

2.3 Description of Data and Stylized Facts
2.3.1 Description of Data: The study uses annual data that covers the period 1990-2014. Logarithmic transformations were made to all data which have been sourced from the World Banks' Development Indicators. The variables of interest are renewable energy consumption; real GDP, CO2 emissions and trade openness.

2.3.2 Descriptive Statistics of Variables: From Table 1 which shows the descriptive statistics, LNRWEC represents log of renewable energy consumption data; LNRGDP, LNCO2, and LNTO are respectively log of real per capita GDP, log of CO2 emission and trade openness index respectively. There is little or no evidence of significant variations in the trends of the series. This can be clearly seen by considering the difference of the minimum and maximum values for each series within the dataset. For kurtosis, Real GDP and CO2 series seem to be platykurtic. This implies that both series produce fewer extreme outliers (thin tails) compared to outliers found in a normal distribution. Trade openness and renewable energy consumption are mesokurtic as indicative of the coefficients of kurtosis which approximates to 3.

Table 1: Descriptive Statistics

	LNRWEC	**LNRGDP**	**LNCO$_2$**	**LNTO**
Mean	4.457498	7.401880	-0.656917	4.028976
Median	4.459550	7.225799	-0.560145	4.090468
Maximum	4.486745	7.848970	-0.260875	4.404434
Minimum	4.418311	7.125072	-1.122774	3.430277
Std. Dev.	0.017295	0.274836	0.294949	0.248857
Skewness	-0.478931	0.410093	-0.272874	-0.950124
Kurtosis	2.631830	1.417929	1.704827	3.520892
Jarque-Bera	1.096927	3.307973	2.057619	4.044031
Probability	0.577837	0.191286	0.357432	0.132388
Sum	111.4374	185.0470	-16.42293	100.7244
Sum Sq. Dev.	0.007179	1.812838	2.087882	1.486316
Observations	25	25	25	25

This implies that both series produce outliers equivalent to those found in a normal distribution (moderate tails). The skewness coefficients indicate that none of the series is highly skewed. LNRWEC, LNCO$_2$, LNRGDP are approximately symmetric (skewness statistics less than 0.5 and closer to 0). LNTO series is moderately skewed (skewness coefficient lies between 0.5 and 1 in absolute terms). The series with the highest standard deviation from the mean is LNCO$_2$ (with a maximum to minimum value ratio of -0.2609 to 1.1228). Nevertheless, using the Jaque-Berra (JB) statistic, the normality assumption cannot be rejected for all series as they are not significantly high. This suggests that an alternative inferential statistic may not be required to ensure the joint normality of the series.

The trend of Nigeria's renewable energy consumption indicates a measure of fluctuations. Within the study period (1990 – 2014), renewable energy consumption peaked in 2009 while the minimum use occurred in 2003. The high level of renewable consumption is attributable partly to the dominance of biomass (fuel wood) in most regions of Nigeria and also the low level of total energy consumption relative to the developed countries. Trends in the Real GDP series have been upwards and relatively stable. Nigeria's Real GDP dropped to a record low in 1987 but has risen steadily thereafter which can be associated with the oil boom. However, there is evidence of changes in the slope of the series. It was steepest between 2003 and 2004 (indicating highest growth rate) associated with the expansion of the non-oil sector (particularly due to the Telecommunications reform and expansion of the services sector) but became flatter thereafter. The oil market crash in 2014 further changed the slope as it became much flatter between 2014 and 2017. CO$_2$ emission makes up the largest proportion of GHGs emitted globally – especially from fossil fuel production and consumption. CO$_2$ emission trend has been irregular - it decreased to a record low of 0.31 metric tons per capita in 1995; hit a peak of 0.76 (Mt/cap) in 2002 and is currently below the 1992 level.

Figure 1 shows the trend of Nigeria's trade openness index. Building from the Structural Adjustment Programme (SAP) of 1986, there was an upward trend in the openness index between 1990 and 2002. The launching of Nigeria's membership of the World Trade Organization (WTO) in 1995 was a major catalyst to this development. However, this has been followed by a downward trend due to a combination trade issues, policy inconsistencies, as well as, restrictions and non-tariff barriers. The movement of the trade openness index as highlighted in Figure 1 has also been non-linear. Nigeria's best performance was in the year 2001. Thereafter, fluctuations were recorded with the series trending downwards on the average to the 2014 level which is way below 30%.

Figure 1: Nigeria's Trade Openness Index 1990-2014
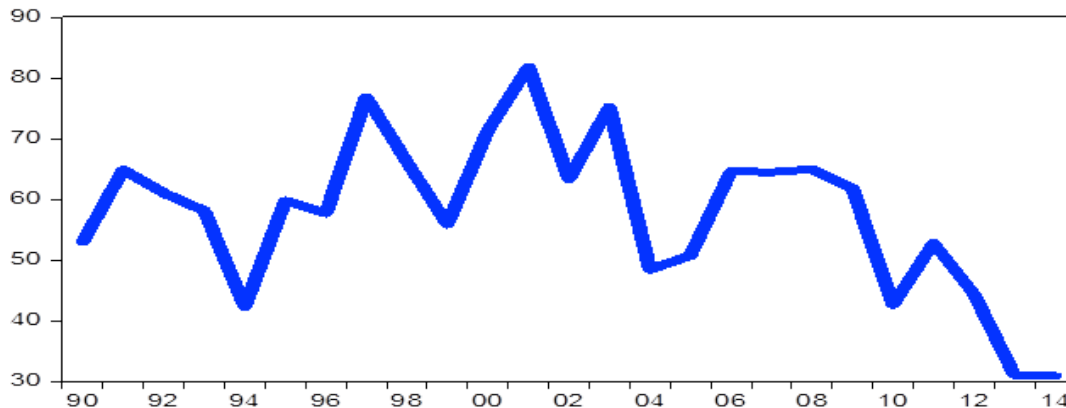
Authors' Illustration based on World Development Indicators Data

3.0 METHODS

ARDL model of estimation proposed by [26] is the methodology adopted in this study. The empirical analysis and econometric techniques adopted align with the general literature. Building on the model of Basak (2016), some of the variables that influence renewable energy consumption have been factored in. However, the paper is contributing to existing literature by incorporating TY approach to empirically analyze the Nigeria situation. It also utilizes error correction modelling to test the variables for granger causality.

3.1 Model

Following the specification of [11], the model can be specified as follows:

$$RWEC_t = f\left(RGDP_t, CO_{2_t}, TO_t\right) \tag{1}$$

where $RWEC_t$ = Renewable Energy Consumption (percentage of renewables in total final energy consumption at time, t

$RGDP_t$ = Real Gross Domestic Product constant US Dollar at time, t

CO_{2_t} = Carbon Dioxide Emission in metric tonne per capita at time, t

TO_t = Trade Openness $\left(\dfrac{\text{Imports} + \text{Exports}}{GDP}\right)$ at time, t

Given the small sample size of available data, the Auto-Regressive Distributed Lag (ARDL) Bounds Test Co-integration approach is used for this analysis. Furthermore, to capture the speed of adjustment to long-run equilibrium due to change in any of the exogenous factors that determine Nigeria's renewable energy consumption, the Error Correction Model is estimated.

The long-run model in its deterministic form is thus specified as follows:

$$RWEC_t = RGDP_t + CO_{2t} + TO_t \tag{2}$$

Finally, the stochastic model is specified as follows:

$$RWEC_t = RGDP_t + CO_{2t} + TO_t + \varepsilon_t \tag{3}$$

where ε_t = Stochastic Error Term at time, t

The Short-run (ECM) model is specified as follows:

$$\Delta RWEC_t = \alpha_0 + \alpha_1 RGDP_t + \alpha_2\, CO_{2t} + \alpha_3 TO_t + \sum_{i=1}^{k} \beta_i \Delta RWEC_{2t-i} + \sum_{i=0}^{j} \beta_{2i}\, \Delta RGDP_{t-i}$$

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$$+ \sum_{i=0}^{g} \beta_{3i}\Delta CO_{2t-i} + \sum_{i=0}^{h} \beta_{4i}\Delta TO_{t-i} + \theta ECT_{t-i} + \varepsilon_{it} \qquad \textbf{(4)}$$

where ECT_{t-i} = Error Correction Term Lagged for 1 period

θ = coefficient of error term

k, j, g, h = lag length of the various variables

3.2 *Estimation Procedure*

In order to ensure the stationarity of the variables of interest, unit root test is conducted on all the series in the model. Thereafter the bounds co-integration technique is used to examine the existence of a long-run equilibrium relationship between the variables. Finally, the Ordinary Least Square technique is used for the estimation of the model after performing the necessary diagnostics.

4.0 RESULTS AND DISCUSSION

4.1 *Unit Root and ARDL Bounds Test*

Two methods were deployed in order to ensure consistency of results. The Augmented Dickey Fuller and Phillips – Perron tests for unit root confirmed that all variables were integrated of order 1, with most results favouring a model with constant over that of deterministic trend. The presence of unit root along with small sample size of data further justifies the adoption of the ARDL approach. The long-run relationship among the variables in the model was examined using the ARDL bounds test approach to co-integration. Out of the different information criteria for optimal lag selection (such as the Akaike information criteria and Schwarz), the Schwarz criteria was employed because it selects the simplest of the models i.e. ARDL (1, 0, 0, 0). To determine the existence of co-integration, the computed F-stat from the Bounds test is compared with the critical values of the lower and upper bounds reported in the co-integration table. The series are co-integrated if the F-stat is greater than the upper bound critical values at 5%. Therefore, the result of the bounds test as presented in Table 2 is inconclusive since the F-stat (3.323) lies between the upper bound (4.35) and the lower bound (3.23). This implies that the long run results can also be interpreted using other checks such as the properties of the ECM term in the short run results. Since the ECM term is well-behaved and significant, it implies that there exists a long run equilibrium relationship among the variables of interest within the period covered by the study.

4.2 *Diagnostics Test*

To justify the interpretation of the long-run regression result above and also make long-run policy inferences, the model must satisfy the basic assumptions of the classical linear regression model. Thus, the diagnostics tests help to ascertain whether these assumptions are violated or satisfied. From the Ramsey Reset Test, the p-value of the F-stat is 0.9539 which implies that it is not significant at 5% to prompt a rejection of the null hypothesis. Hence, it is posited that the regression model is linear and correctly specified. However, the null hypothesis of no serial correlation can be safely rejected for the model using the residuals and residual squared 'metric' of the LB Q - stat is statistically significant in lags 2 and 10 at the 5% level. This implies that this fundamental OLS assumption is violated and as such the results from the model becomes unreliable for policy analysis.

However, the model was adjusted by adopting the Newey-West HAC regression which corrects for both serial correlation and heteroskedasticity by modifying the standard errors and T-stats. The Breusch-Pagan-Godfrey test was employed to test for heteroscedasticity in the model. The p-value of 0.2639 also indicates the absence of heteroskedasticity in the model. The Jacque Berra Normality test show that the residuals from the regression model are normally distributed as can be verified from the table above. Since the regression model satisfies the CLRM assumptions, both long-run and short-run results can be interpreted.

4.3 *Long-run Dynamics*

The long-run results show that Real GDP and CO2 Emissions are the significant drivers of renewable energy consumption for Nigeria in the long-run. On the other hand, Trade Openness was found to be statistically insignificant. All variables conformed to general literature and apriori expectation (even though the latter was not significant). The long-run coefficient of Real GDP is 0.0457. This implies that a percentage increase in the

mean of per capita RGDP will lead to a 0.0457 percentage increase in the level of renewable energy consumption. This shows that renewable energy consumption in Nigeria exhibits the income effect in the long run.

The long-run coefficient for CO_2 emissions is -0.0587. This implies that a percentage increase in the mean of per capita CO_2 emission will lead to a 0.0587 percent decrease in the volume of renewable energy consumption. This implies that in the long run, environmental degradation resulting from emission does not promptly drive interest in cleaner energy sources. Thus, renewable energy consumption is not yet a substitute for fossil fuels. The p-value of the F-stat is 0.0001 which shows that the overall model is statistically significant at 5%. This is also reflected in the adjusted R-squared of 0.6213, indicating that over 62% of the total variations in renewable energy consumption is explainable and/accounted for by the determinants as specified in the model. This also shows a strong goodness of fit.

Table 2: Presentation of Results

Variable	Level		First Difference	
	ADF	**PP**	**ADF**	**PP**
LNRWEC	-2.537[a]	-2.537[a]	-4.978[a]**	-5.103[a]**
LNRGDP	-2.199[b]	-2.193[b]	-3.777[a]**	-3.777[a]**
LNCO2	-1.434[a]	-1.434[a]	-4.041[a]**	-4.013[a]**
LNTO	-2.401[b]	-2.401[b]	-6.521[a]**	-7.115[a]*

Co-integration Test Results

Note: **'a'** signifies a model that does not have a deterministic trend but has a constant. **'b'** indicates a model that has a constant, as well as, a deterministic trend. * indicate the series is stationary at 1% while **, *** represent stationarity at 5% and 10% respectively. ADF and PP represent Augmented Dickey-Fuller and Phillips-Perron unit root tests respectively.

Summary of Toda Yamamoto Causality Result

Dependent Variable	*LNRWEC*	*LNRGDP*	$LNCO_2$	*LNTO*
LNRWEC		0.3475 (0.5555)	2.9869 (0.0839) ***	0.8709 (0.9900)
LNRGDP	0.3335 (0.5636)		0.1681 (0.6818)	0.3979 (0.5281)
$LNCO_2$	0.2647 (0.6069)	0.05960 (0.8071)		0.137046 (0.7112)
LNTO	11.3538 (0.0008) **	1.3767 (0.2407)	5.5747 (0.0182) **	

Note: *, ** and *** represent 1%, 5% and 10% level of significance respectively at which the null hypothesis of no serial correlation can be rejected. Figures in parenthesis are probability values.

4.4 Short-run Dynamics

The short-run estimates of the ARDL error correction model (ECM) were derived using the minimum Schwarz Criterion. The results of the short-run can be found in Table 2. The analysis explored the option of a more parsimonious model, but the redundant variable test revealed that most of the insignificant variables were found to be jointly significant in the model. This is because the R^2 from the redundant variable regression was less than the R^2 from the general regression result. Hence, the short-run results can be interpreted from the original model. The short-run elasticity coefficient of RGDP is 0.0394. This implies that in the short-run, a percentage increase in RGDP will bring about a 0.0394 percentage increase in renewable energy consumption. Thus, it can be concluded that the huge cost of renewable energy investments is a deterrent to its consumption in the short-run even amidst the potential positive effect of rising GDP. The short-run elasticity coefficient of CO_2 emission (-0.0506) is statistically significant. Its negative coefficient indicates that the long run outcome explained above builds from the short run. This implies that renewable energy consumption is not a substitute for fossil fuels in the short run and as such increase in CO_2 emission does not immediately induce switching to renewable energy sources. For trade openness, the short-run coefficient is not statistically significant.

Finally, from the results the coefficient of the ECM term is well-behaved – less than one, significant and conforms to apriori expectation (negativity). Its coefficient of -0.86219 implies that about 86% of the deviations from long-run equilibrium are corrected in each year which is quite quick. This implications of these results aligns with and reaffirms the conclusion of [31] on the need for unified energy planning road map which integrates renewable sources.

4.5 Toda Yamamoto (TY) Causality Analysis
Given that the model is co-integrated, the Toda Yamamoto causality test was employed to determine the causal relationship between renewable energy consumption and its determinants. This is because of its robustness and reliability even in the face of the unit root problem that is typical of time series data. The traditional granger causality test is vulnerable to spurious regression in the presence of non-stationary time series as it assumes that the series are stationary at level form [16]; [20]. The TY model evidently involves the VAR-granger causality testing but in a very unique way which accounts for and removes the effects of unit roots, namely spurious regressions in the results of the analysis [28].

The TY causality result, in Table 2, captures the variables in their level form, not first differences. Since the level forms of all the variables are statistically insignificant, it is apparent that all other variables have no causal impact on CO_2 emission. However, there is strong unidirectional causality running from renewable energy consumption to trade openness, and from carbon emission to trade openness. However, the unidirectional causality from carbon emission to renewable energy consumption is very weak.

5 CONCLUSION

This study adopted the ARDL bounds estimation approach to empirically analyze the determinants of Nigeria's renewable energy consumption between1990-2014. The following conclusions can be drawn from the results. First, all variables were integrated of order one which implies that the treatment of stationarity is important in modeling the determinants of renewable energy consumption and for useful inferences to be drawn from results. Second, there is a long-run equilibrium relationship between renewable energy consumption and its determinants in Nigeria. Basically, real income (real GDP) and CO2 emission are the most significant drivers with their long-run coefficients being 0.0457 and -0.0587 respectively.

In the circumstance, Nigeria stands a good chance to seek Green Climate Fund projects in renewable energy and thereby, reduce CO_2 emissions. However, the Green Climate Fund (GCF) lacks the financial resources and effective governance to support developing countries – who also lack the capacity to develop projects for assessing the Fund [33]. Meanwhile, trade openness does not drive the consumption of renewables in Nigeria within the study period. The economic implication of this is that environmental considerations are less critical than real income to the consumption and development of renewable energy in Nigeria. As such, renewable energy can not be the substitute to fossil fuels in Nigeria in the meantime.

Third, there exists unidirectional causality running from CO2 emission and renewable energy consumption to trade openness, which implies both fossil-based energy sources and renewables can be viable tools for improvement in trade liberalization in Nigeria. This further makes a case for supply-side management policies to be implemented so as to improve the energy mix to favour natural gas which is so far the cleanest fossil fuel. Therefore, it is recommended that future research in this area focus on testing for structural breaks in this model whilst explaining the causes of such if identified. Furthermore, from a macroeconomic perspective, it is evident that polices driving increased renewable energy consumption will result in more imports of the technology – since they are not locally sourced. However, with such trade openness, there are foreign exchange implications for the local currency, especially in the light of government's goal to diversify from crude oil export. Such a situation could actually make potential export commodities costlier to produce – if the energy generating technologies are imported – disadvantageous to the nation's industrialization goal.

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