
IMPACT OF RENEWABLE ELECTRICITY GENERATION ON ECONOMIC OUTPUT IN NIGERIA

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Abstract:

Electrical power is an important component for the development of any economy and is responsible for prosperity. This study investigated the impact of hydroelectricity power generation on economic output in Nigeria, presented over the period of 1980-2020, using the ARDL method. Unlike other existing studies that checked the effect of renewable electricity consumption on economic development or environmental sustainability for different countries, this study further presented the casual relationship between economic output and hydroelectricity generation in Nigeria. It employed the Bounds testing approach for cointegration relationship and the Granger causality test due to TYDL technique. The findings of the study revealed that there is no causality between hydroelectricity power generation and aggregate output in Nigeria. Based on the findings of the study, it was recommended among others that policies aimed at boosting the generation and distribution of hydroelectricity power supply in Nigeria should be maintained and improved. This in turn would have a positive impact on the economy, as electricity generation from renewable sources is one of the objectives of sustainable development.

Keywords: causality, economic growth, gross domestic product, hydroelectricity

1.0 INTRODUCTION

Energy is the basic building chunk to all sectors of modern economic growth and it is considered an essential source for all kinds of production activities, i.e., more energy is expended to running machines, vehicles, to manufacturing goods (Zafar et al., 2019). The target of every country's economy be it developing, emerging, or developed country is to achieve sustainable development (Ali et al., 2020). Renewable energy is considered to be a prerequisite for the achievement of long-term economic growth and development. Hydro, solar, biomass, geothermal energy, and wind are the most common renewable energy sources in Nigeria. Electricity has become a necessity and an integral part of day-to-day living due to its relationship with human's industrial production, agricultural productivity, health, education, etc. (Asumadu-Sarkodie & Owusu, 2017).

Odekanle et al. (2020) stated that the constant availability of energy supply for industrial, domestic, and agricultural purposes is a strong indicator of a community's infrastructural development. In fact, energy consumption is a reflection of a nation's development due to its immense contribution to socio-economic growth. By harnessing renewable resources and deploying alternative technologies, Nigeria might attain a consistent power supply and increased energy efficiency. The federal government of Nigeria has changed the electrical sector in order to entice private investors to increase renewable energy supplies. According to research by Onochie and Egware (2015), Nigeria is heavily reliant on a few operational thermal and hydro power plants. Nigeria's entire exploitable large-scale hydropower potential is currently projected to be around 14,120 MW, capable of providing 50,832 GW of electricity annually.

What are the macroeconomic determinants of hydroelectricity power generation in Nigeria? How does hydroelectricity power generation impact on disaggregate output of the manufacturing and service sectors in Nigeria? What is the causal relationship between hydroelectricity power generation and aggregate output in Nigeria? These are the research questions that this study intends to answer by providing empirical evidence which could influence policy formation.

The main aim of this study is to investigate how the country performs economically concerning its output with the use of hydroelectric power in the case of Nigeria over the period of 1980–2020. Streamlining it down to specifications, the objectives are to:

- i. Evaluate the macroeconomic determinants of hydroelectricity power generation in Nigeria.
- ii. Examine the impact of hydroelectricity power generation on disaggregate output of the manufacturing and service sectors in Nigeria.
- iii. Examine the causal relationship between hydroelectricity power generation and aggregate output in Nigeria.

The paper analyses five organized sections: introduction, literature review, database and methodology, results, and conclusions and final remarks.

2.0 LITERATURE REVIEW

Oderinde and Isola (2011) investigated the causality relationship between electricity consumption and output performance in Nigeria and Ghana. They used annual data series from 1970 to 2006 to examine the causal relationship between output per worker, electricity consumption per worker, primary exports per worker, and capital per worker in a multivariate model for Nigeria and Ghana. Bounds testing approach for cointegration relationship and the Granger causality test due to Toda and Yamamoto (1995) and Dolado and Lutkepohl (1996) were employed. The results

indicated no causality in Nigeria but there is causality only from output to electricity consumption in Ghana.

Durgün and Durgün (2018) investigated the relationship between GDP per capita and renewable energy consumption per capita in Turkey from 1980 to 2015. The study was conducted using the ARDL boundary test and cointegrated Toda-Yamamoto causality test, and a one-way causality relationship was found from renewable energy use to economic growth.

Nkalo et al. (2018) reviewed the impact of electricity supply on economic growth. In the background, power supply in Nigeria was studied from 1983 to 2017. Results obtained showed that 100% of stake holders and 68% of the general public in Umudike, Abia State, Nigeria agree that power supply in Nigeria has improved in recent times. For every 1% increase in electricity supply, an economy is expected to grow by 3.94%. Inversely, a 1% increase in real gross domestic product leads to a 0.34% increase in electricity supply and consumption. Although, with an improved current generating capacity of 7000 megawatts and distribution capacity of 4600 megawatts, factors such as an increase in load growth, poor maintenance of existing transmission and distribution facilities and lack of adequate physical structure still cause epileptic power situation in most parts of Nigeria. The study recommended that policies aimed at boosting the generation and distribution of electricity supply in Nigeria should be maintained. This in turn would have a positive impact on the economy.

Stamatios et al. (2018) examines the relationship between energy consumption derived from renewable energy sources, and countries' economic growth expressed as GDP per capita concerning 25 European countries. The used dataset involves European countries' data for the period from 2007 to 2016. The statistical analysis was based on descriptive statistics, cluster analysis, and autoregressive distributed lag (ARDL), and reveals that all variables are related; this suggests a correlation between the dependent variable of GDP and the independence of renewable energy sources (RES) and Non-RES energy consumption, gross fixed capital formation, and labour force in the long-run. Furthermore, the results showed that there was a higher correlation between RES' consumption and the economic growth of countries of higher GDP than with those of lower GDP.

Bulut and Inglesi-Lotz (2019) revealed the statistically significant and positive influence of renewable energy consumption on economic development in 34 OECD countries. The feedback hypothesis showed economic development and usage of biomass energy for Q1 of 1991 to Q4 of 2015 for the countries of the BRICS region. Energy is a main ingredient in the process of production and the backbone of the industrial sector, hence in this sense, the targets of economic growth cannot be achieved without the use of energy sources, and concurrently economic growth increases the level of energy use. Since 1973, during the period of oil crises, the

theory of unit elasticity has taken importance. According to this theory, a unit change of economic growth leads to one unit change in use of energy sources, as was apparent in OECD countries during the 1973–74 oil crises.

Mustapha et al. (2021) studied the impact of the electricity crisis on the economic growth of Nigeria is presented. Unlike other existing studies that checked the effect of electricity consumption on economic development or environmental sustainability for different countries, the study presented a techno-economic analysis of a proffered solution to the imminent electricity crisis. Timeseries regression models are used to analyze the effect of electricity consumption on economic development and environmental sustainability while RET Screen professional software was used to perform a techno-economic analysis and determine the feasibility of a 500-kW microgrid Solar Photovoltaic (PV) system integrated for electricity generation. From the analysis results, a strong positive correlation effect was evident between electricity consumption and GNI, as well as a strong negative correlation between electricity consumption and gross domestic savings. Also, strong positive correlation effects are evident in the case of carbon emissions by buildings, by the power industry, and by other combustion industries on electricity consumption in Nigeria. Considering the net present value, internal rate of return and payback periods, the use of solar PV systems for electricity generation was feasible in the 12 different locations in Nigeria studied in the research. The most feasible area for solar PV installation was the northern part of Nigeria as Gombe and Kaduna recorded a simple PBP and an equity PBP are 6.3 years and 7.4 years respectively.

Li et al. (2021) examined the relationship between renewable energy sources and economic growth of the South Asian Association for regional cooperation (SAARC) countries. This study used three main renewable energy sources, namely geothermal, hydro, and wind. The study collected data sets from SAARC countries from 1995 to 2018 and applied a fixed effect test and panel vector error correction model (PVECM) for data analysis. The overall results showed that all three renewable energy sources had a positive significant impact on economic development among SAARC countries' economies. Moreover, hydropower renewable energy had more effects and influences on economic growth as compared to the other two individual sources of renewable energy.

Anam et al. (2021) examined the short- and long-run of the causal correlation between economic growth and renewable electricity generation sources for a panel of 25 developing nations over the period 1990–2017. To do so, second-generation cross-sectional dependence (C.D.) test Im, K.S., Pesaran and Augmented Dickey Fuller panel unit root test, panel cointegration, autoregressive distributed lag in view of the pooled mean group estimation and panel heterogeneous Dumitrescu Hurlin (2012) causality methods were utilized. The main findings indicated that the positive and significant impact of renewable electricity generation on economic growth showed

that renewable electricity generation sources stimulated economic growth in the long run for these selected countries. It is also demonstrated that there was bidirectional causality between renewable electricity generation and economic growth both in the short run and long run. Based on their findings, the feedback hypothesis was valid for developing countries

3.0 METHODOLOGY

Theoretical framework

The theory used in this study is the theory of energy in the production function (propounded by J.H. von Thunen) similar to the study of (Pokrovski, 2003), who investigated the fundamental role of energy as a factor of production. The theory was an extension of the conventional two-factor theory of economic growth, where capital is the means by which the labor resource is substituted by energy rather than a production factor itself. In this regard, the energy in the production function is electricity. It is therefore assumed that hydroelectricity as a form of energy is used for efficient growth of economic output.

$Y = f(K, L)$ representing the production function.

Inputting energy into the production function we have,

$$Y = f(K, L, E)$$

Where Y = the output,

K = the capital,

L = the labour and

E = electricity.

Inputting electricity into the production function of firms.

Model Specification

The economic model applied in this study follows the Neo-Classical Model of economic growth.

The model is as follows:

$$Y = A K^\alpha L^\beta \dots\dots\dots (1)$$

$$\text{GDP} = \log A + \alpha \log K + \beta \log L + u \dots\dots\dots (2)$$

For the economy to grow energy is introduced.

$$Y = A K^\alpha L^\beta E^\varphi \dots\dots\dots (3)$$

The econometric model can be specified as;

$$GDP = \log A + \alpha \log K + \beta \log L + \varphi \log E \dots \dots \dots (4)$$

Where;

GDP = Gross Domestic Product

K = Capital

L = Labor

E = Energy

From equation (4) the production model can be specified as

$$GDP = \log A + \alpha \log K + \beta \log L + \varphi \log E + u \dots \dots \dots (5)$$

The model to be estimated are as follows:

$$GDP = f(\text{INFR}, \text{HEP})$$

$$\ln GDP_t = \alpha - \alpha_1 \ln \text{INFR}_t + \alpha_2 \ln \text{HEP}_t + \mu_t \dots \dots \dots (6)$$

where;

GDP = Gross Domestic Product

HEP = Hydroelectricity Power Generation

INFR = Inflation Rate

where ln represents the logarithm and μ represents the error term.

Toda and Yamamoto (1995) and Dolado and Lutkepohl (1996) developed a new procedure of Granger causality based on an augmented VAR modelling by introducing a modified Wald tests (MWald) statistics, and it can be applied with all the integration series types I(0), I(1) and I(2) for both non co-integrated or co-integrated variables, the TYDL (Toda, Yamamoto, Dolado and Lutkepohl) procedure composes from four steps; the first step is to find the maximum order of integration between the variables, where d_{max} is the higher order of integration, the second step is to determine the optimal lag order (K) of VAR model in levels as usually chosen by Akaike information criterion (AIC), Schwarz information criterion (SIC), Hannan-Quin information criterion (HQ), the final prediction error (FPE) and the sequential modified LR test statistics (LR), the third step is to estimate the VAR model (VAR(K+ d_{max})). Finally, the TYDL procedure uses the MWald test statistics to test the causal relationships between the variables.

The Toda and Yamamoto (1995) and Dolado and Lutkepohl (1996) (TYDL) Granger no-causality test is implemented for this model by estimating the following

multivariate VAR system using the Seemingly Unrelated Regression (SUR) technique:

$$\ln \text{gdp}_t = c_1 + \sum_{i=1}^{p+q} \alpha_{i1} \ln \text{gdp}_t + \sum_{i=1}^{p+q} \alpha_{i2} \ln \text{hep}_t + \sum_{i=1}^{p+q} \alpha_{i3} \ln \text{infr}_t + e_t \quad (7)$$

$$\ln \text{hep}_t = c_1 + \sum_{i=1}^{p+q} \alpha_{i1} \ln \text{hep}_t + \sum_{i=1}^{p+q} \alpha_{i2} \ln \text{gdp}_t + \sum_{i=1}^{p+q} \alpha_{i3} \ln \text{infr}_t + e_t \quad (8)$$

$$\ln \text{infr}_t = c_1 + \sum_{i=1}^{p+q} \alpha_{i1} \ln \text{infr}_t + \sum_{i=1}^{p+q} \alpha_{i2} \ln \text{hep}_t + \sum_{i=1}^{p+q} \alpha_{i3} \ln \text{gdp}_t + e_t \quad (9)$$

From equation (10) hep does not granger cause gdp if $H_0: \alpha_{11} = 0$ against $H_1: \alpha_{11} \neq 0$ where $i = \text{hep}$. In the same equation, infr does not granger cause gdp if $H_0: \alpha_{21} = 0$ against $H_1: \alpha_{21} \neq 0$ where $i = \text{infr}$. The same pattern is followed for equation (11) and (12) to judge the causality relationship between the variables on the right and the respective dependent variable.

Data

This study is set to source data and analyze for over a period of 40 years that is from the year 1980 to the year 2020. The data was gotten from the world bank indicators, and the statistical bulletin. The variables analyzed and their measurements included are, hydroelectricity generation (%), Real interest rate (%), Services, value added (% of GDP), Foreign direct investment, net inflows (% of GDP), General government final consumption expenditure (% of GDP), GDP in billions (\$), Manufacturing output in billion (\$), Inflation rate in (%). In relation to the evaluation of macroeconomic determinants of hydroelectricity power generation in Nigeria, Hydroelectricity Power Generation depends on Gross Domestic Product and inflation rate and foreign direct investment. To examine the impact of hydroelectricity power generation on disaggregate output of the manufacturing and service sectors in Nigeria, Manufacturing output depends on Hydroelectricity Power Generation, Interest Rate and Foreign direct investment, and government expenditure, this is exclusively for the manufacturing sector while for the service sector, service output depends on Hydroelectricity Power Generation, interest rate, Foreign direct investment and Government Expenditure. To examine the causal relationship between hydroelectricity power generation and aggregate output in Nigeria, Gross Domestic Product depends on Hydroelectricity Power Generation, and Inflation Rate.

4.0 RESULTS AND DISCUSSION

Results

Table 1: Descriptive statistics to examine the causal relationship between hydroelectricity power generation and aggregate output in Nigeria.

	LGDP	INFR	HEP
Mean	4.847	0.188	30.937
Median	4.576	0.126	32.586
Maximum	6.304	0.728	41.865
Minimum	3.323	0.054	17.591
Std. Dev.	0.944	0.167	6.793
Skewness	0.210	1.863	-0.395
Kurtosis	1.496	5.314	2.082
Jarque-Bera	4.164	32.857	2.505
Probability	0.125	0.000	0.286
Sum	198.705	7.699	1268.426
Sum Sq. Dev.	35.665	1.118	1845.703
Observations	41	41	41

Authors Computation 2022

The descriptive statistics of the variables in the model for Nigeria is presented in Table 4.19. The average value of Gross Domestic Product (lgdp) within the period as the table showed is 4.85 and it ranged from a maximum of 6.30 to a minimum of 3.32 and the standard deviation is 0.94. For Inflation rate (infr) the maximum was 0.73, average of 0.19 minimum value of 0.05, while the standard deviation was 0.17. Considering the case of Hydroelectricity Power Generation (hep) the average value is 30.94, with its maximum value and minimum value being 41.86 and 17.59 respectively. The standard deviation of (hep) is 6.79.

Table 2: Unit Root Test Result to examine the causal relationship between hydroelectricity power generation and aggregate output in Nigeria.

Variables	ADF Statistics (At levels)	ADF Statistics (At 1 st diff.)	Order of Integration
lgdp	-0.411	-6.718	I(1)
infr	-3.508	-6.367	I(0)
hep	-1.681	-8.532	I(1)
Critical value at 1%	-3.611	-3.611	
Critical value at 5%	-2.939	-2.939	
Critical value at 10%	-2.608	-2.608	

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The result of the unit root test conducted using the Augmented Dickey-Fuller test statistic revealed that the variables (Gross Domestic Product, Inflation Rate, and Hydroelectricity Power Generation) are non-stationary but the maximal order of integration of the two variables (Gross Domestic Product and Hydroelectricity Power Generation) is one while the variable for Inflation Rate is integrated at levels. The variables became stationary after differencing them at levels and once (see table 4.20). Following the result, the series are integrated at levels and in the first order, the test for cointegration (long -run) relationship will have to be robust enough to accommodation characteristics of the data. Therefore, the ARDL approach was adopted.

Table 3: ARDL Bounds Testing for Cointegration Analysis to examine the causal relationship between hydroelectricity power generation and aggregate output in Nigeria.

Computed F-statistic: 1.556171 (lag structure, k = 2)
Critical bound's value at 5% Lower: 3.79 and
Critical bound's value at 1% Lower: 5.15 and Upper: 6.36
(Three regressors and no trends in the model)

The result of this (presented in table 4.21) showed that the F-statistics is lower than the lower and upper bound at 5%, therefore there is no long-run equilibrium relationship between the dependent and independent variable. Which means that the hypothesis of the existence of long run relationship among variables Gross Domestic Product, Inflation Rate, and Hydroelectricity Power Generation could be rejected over the period of analysis. Therefore, we can conclude that in there is no cointegration relationship among the variables included in the model. For the evaluation of causality relationship, the TYDL approach was adopted.

Table 4: VAR Lag Order Selection Criteria to examine the causal relationship between hydroelectricity power generation and aggregate output in Nigeria.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-144.9080	NA	0.4824	7.7846	7.9139	7.8306
1	-71.2979	131.7233*	0.0161*	4.3841*	4.9012*	4.5681*
2	-64.7553	10.6747	0.0186	4.5134	5.4184	4.8354
3	-55.7209	13.3139	0.0190	4.5116	5.8045	4.9716

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* Indicates lag order selected by the criterion; LR: sequential modified LR test statistic (each test at 5% level); FPE: Final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion

The implementation of TYDL non-causality test proper requires we establish the optimal lag length of VAR model first. This was done through the use of various model selection criteria among which are Akaike information criterion (AIC), Schwarz information criterion (SIC). The result as presented in Table 4.22 shows that the optimal order of the VAR model should be one if (SIC) is used. The other criteria select optimal order other than one for the model but one is used in consonance to the SIC criteria due to the small sample size of series in order to preserve some degrees of freedom for the estimation.

Table 5: TYDL Multivariate Granger causality test (χ^2 statistics) to examine the causal relationship between hydroelectricity power generation and aggregate output in Nigeria.

	Lgdp	Infr	hep
Lgdp		2.7648 (0.2510)	2.2094 (0.3313)
Infr	1.5757 (0.4548)		0.2012 (0.9043)
Hep	1.3334 (0.5134)	1.6672 (0.4345)	

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Figures in parenthesis are p-values.

The TYDL Granger causality test was conducted using the modified Wald (MWald) test to verify whether the coefficients of the lagged variables are significantly different from zero in the respective estimated equation (table 4.23) specified earlier. The result is presented in table 4.23. Following the objective of the study which is to examine the causality relationship between hydroelectricity power generation and aggregate economic output in the presence of other relevant variables in a well-articulated analytical framework, it is found that in the case where Gross Domestic Product is the dependent variable and Inflation Rate and Hydroelectricity Power Generation are the independent variables, the independent variables are more than 5% and here we cannot reject the null hypothesis, therefore there is granger non-causality from Inflation Rate, and Hydroelectricity Power Generation to Gross Domestic Product. In the case where Hydroelectricity Power Generation is the dependent variable and Gross Domestic Product and Inflation Rate are the independent variables, the independent variables are more than 5% and here we cannot reject the null hypothesis, therefore there is granger non-causality from Inflation Rate and Gross Domestic Product to Hydroelectricity Power Generation.

In the case where Inflation Rate is the dependent variable and Gross Domestic Product and Hydroelectricity Power Generation are the independent variables, the independent variables are more than 5% and here we cannot reject the null hypothesis, therefore there is granger non causality from Gross Domestic Product and Hydroelectricity Power Generation to Inflation Rate.

Discussion

The result, in a nut shell, did not provide clear econometric evidence in support of causality relationship between hydroelectricity Power Generation and aggregate output in Nigeria in neither direction within the period covered by this analysis. The finding of this study correspond with the results of Oderinde and Isola (2011) where they found out that there is no causality relationship between electricity consumption per worker and output per worker in Nigeria. The study showed that when other relevant variables are accounted for within a more robust framework the causality relationship may break down. The implication of the result for Nigeria is that, in order to encourage the renewable electricity market to improve and grow, the Renewable Energy Master Plan (REMP) policy should be adopted to increase the generation of total renewable electricity in Nigeria.

5.0 CONCLUSION

The main objective of this study was to examine the impact of hydroelectricity power generation on economic output in Nigeria. The paper focused on the Nigerian economy and used annual data from 1980 to 2020. The econometric analysis was conducted employing the VAR procedure to examine the causal relationship between hydroelectricity generation and aggregate economic output. The findings, indicate that the study has investigated the impact of hydroelectricity power generation on economic output in Nigeria. In examining the macroeconomic determinants for hydroelectricity power generation, there is no long-run equilibrium relationship between the dependent and independent variable, which means there is no co-integration relationship among the variables included in the model. For output from both the manufacturing sector and service sector, there is long-run equilibrium relationship between the dependent and independent variable, which means there is co-integration relationship among the variables included in the model. In evaluating the causal relationship between hydroelectricity power and economic output the TYDL Granger causality test was employed, which showed in the result that, there is granger non-causality from the variables.

The research makes its contribution by providing estimates of the impact of renewable electricity generation on economic output in Nigeria, thereby encouraging the government to invest in hydroelectricity which will in turn create employment opportunities for those in the field of energy in the country. This would make the service and manufacturing sector more efficient, effective and more capable to execute its duties with attendant employment opportunities that would also be open leading to an increased standard of living. The research suggests the need to carry out a resource survey and assessment to determine the total renewable energy

potential in the country and how hydroelectricity can be depended upon because of its sustainable development benefits as a source of clean energy, and the local conditions and local priorities in various ecological zones in Nigeria.

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