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RESEARCH ARTICLE

# ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH: THE NIGERIAN CASE

***David Iheke Okorie and Sylvester Adasi Manu**

Wang yanan Institute for Studies in Economics (wise), Xiamen Univeristy, China

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**ABSTRACT**

The objective of the study is to evaluate the causal relationship between electricity consumption and economic growth in Nigeria for the period of 1980 to 2014. The study employed the analysis of Johansen co-integration and VAR-based techniques. A long run relationship exists among the variables. The result shows that in the long run, electricity consumption has a similar movement with economic growth, following the positivity hypothesis. The Granger causality test reveals that there is a unidirectional causal relationship between electricity consumption and economic growth. The study recommends that the industries increase daily generation of power to meet up with the increasing demand for power, more plant stations should be built, and the alternatives to power supply by PHCN should be made more competitive so as to increase productions and the output of the economy as a whole.



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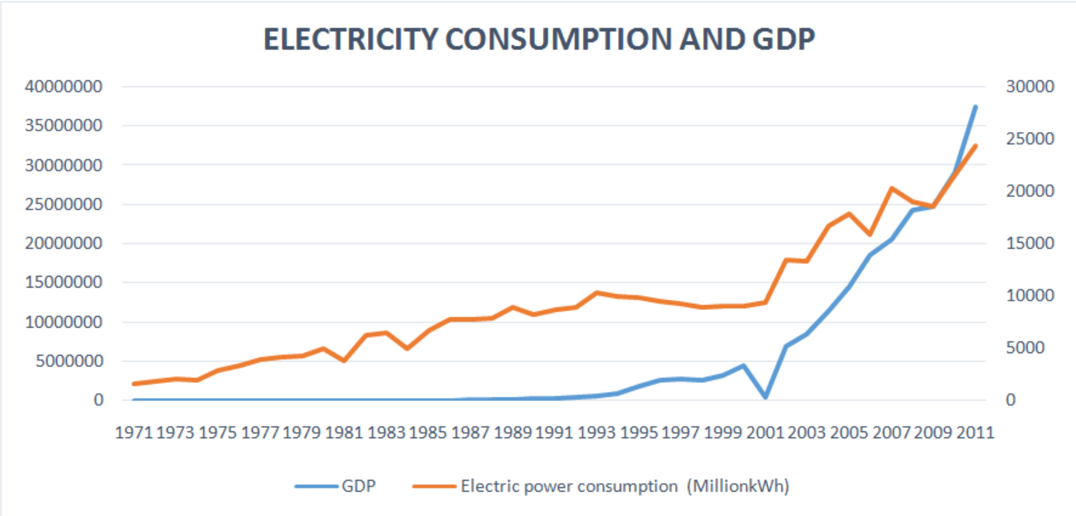
## INTRODUCTION

Energy has been described as a critical factor in the achievement of economic growth and development. This implies that countries trying to achieve economic growth need to constantly provide energy sources. It serves as an intermediate input to production and thus changes in its quality and quantity affect the profitability of production and the productivity of other factors of production. Given the role of energy in the economy, most governments especially in developing countries intervene extensively in the energy market. It is not recent knowledge that Nigeria has abundant natural resources which include coal, lignite, natural gas, crude oil, solar, hydro, nuclear, wood fuel, geothermal, tide, biogas and biomass. Also, the nation relies heavily on the output of the energy sector as it usually consolidates the activities of the other sectors which provide essential services to direct the production activities in agriculture, manufacturing, mining, commerce, amongst others (Onakoya *et al*, 2013). Despite this abundance of natural resources, the citizens still suffer from epileptic power supply. The frequent power outages have been seen to be dependent on the low generating capacity relative to the installed capacity. Several governments of Nigeria have in the past and present pursued the goal of providing constant electricity supply in all the parts of the country. Despite the huge investments made in the power sectors by several administrations over the years, there has been little or no significant improvement on the supply of electricity. There is also the fact that the Nigerian economy has reflected a steady increase in growth over the years even with a power sector that functions below par. The size of the economy marked by the Gross National Income per capita is put at $2,710(World Bank, 2014). On economic growth, the GDP (PPP) per capita of Nigeria is currently at $6, 082 ranked 124th out of 214 countries (World Bank, 2014). The severity of this malaise led to the restructuring of the economyin 1986. Between 1988 and 1997 which constitutes the period of structural economic adjustment and liberalization, the GDP responded to economic adjustment policies and grew at a positive rate of 4 percent. In 2013, the real GDP growthrate was 5.4 percent (World bank, 2014) The average power per capita (in watts)in USA, Japan, United Kingdom, South Africa, China, India, Ghanaand Nigeria were 1,683, 774, 662, 495, 458, 90, 29, and 12 respectively. According to the World factbook (2008), there is a close relationship between the average power per capita and the GDP per capita of the countries.

Two schools of thought exist in the literature on the relationship between energy consumption and economic growth. The first school of thought are of the opinion that energy consumption is a crucial factor for the achievement of economic growth in any nation. They rest their proposition on the belief that energy has a role to play in the achievement of economic, social and technological progress and also exists to supplement the efforts of other factors of production (labor and capital) (Ebohon, 1996; Templet, 1999). On the other hand is the second school of thought which believes that energy plays a minimal to a non-existent role in the production process.

**Corresponding author: David Iheke Okorie,*
Wang yanan Institute for Studies in Economics (wise), Xiamen Univeristy, China




Source; Authors' computation based on World Bank data (2014).

**Figure 1. Trend of Electricity consumption and Gross Domestic Product**

**Table 1. Electricity Generation and Consumption**

| Year | Electricity production (Million kWh) | Electric power consumption (Million kWh) | Electric power consumption (kWh per capita) | Electric power transmission and distribution losses (Million kWh) | Electric power transmission and distribution losses (% of output) | Electric power consumption (Million kWh) (% of output) |
|---|---|---|---|---|---|---|
| 1980 | 7,169.00 | 4,997.00 | 67.80 | 2,084.00 | 29.07 | 69.70289 |
| 1985 | 10,221.00 | 6,723.00 | 80.13 | 3,358.00 | 32.85 | 65.77634 |
| 1990 | 13,463.00 | 8,291.00 | 86.71 | 5,172.00 | 38.42 | 61.5836 |
| 1995 | 15,857.00 | 9,876.00 | 91.09 | 5,981.00 | 37.72 | 62.28164 |
| 2000 | 14,727.00 | 9,109.00 | 74.13 | 5,618.00 | 38.15 | 61.85238 |
| 2005 | 23,539.00 | 17,959.00 | 128.66 | 5,580.00 | 23.71 | 76.29466 |
| 2010 | 26,121.00 | 21,624.00 | 135.40 | 4,497.00 | 17.22 | 82.78397 |

Source; Authors' computation based on World Bank data (2014).

This belief is generally described as the '*neutrality hypothesis'* as propounded by Yu and Choi (1985). Their belief rests on the premise that energy consumption represents a much smaller portion than labour and capital in the production process and thus, the gross domestic process (GDP) and that this portion is so small that it should not affect economic growth. Paradoxically, while Nigeria is blessed with an abundance of energy resources, particularly oil; its people and economy suffer from scarcity of electricity. This is manifested by the epileptic supply of electricity and continuous shortage of most petroleum products. This trend calls for an enquiry to find out the nature of relationship between electricity consumption and economic growth in the Nigerian context. The nature of the causal relationship would prove extremely useful because an economy heavily dependent on electricity, government policies on energy conservation could prove to have adverse effects on economic growth. This rest of study is organized into four sections beginning with section two which reviews some literature in the area of study whilst section three involves the methodology adopted for the study. Section four is the analysis and presentation of data. The concluding section summarizes the findings of the study and provides some policy recommendations.

## Literature Review

An economy consists of people effecting changes in the states of the world consisting energy and matter. Since no change can be effected without the expense of energy, energy can thus be seen as an indispensable force driving all economic activities (Alam, 2008). Energy is also considered a factor for economic growth since production is affected by energy (Stern, 2000; Jumbe, 2004). Energy consumption shows the total amount of energy consumed by each industry and household in an economy. In Nigeria, sources of energy consumed are coal, crude oil, natural gas, lignite, hydro, nuclear and geothermal electricity and recently, the solar source of energy is being introduced. The theoretical literature selected for this work include the Physical Theory of Economic Growth by Kardashev (1964) which posits that energy is indeed necessary for economic production and therefore growth. Reproducibility is a key concept in the economics of production. Therefore, natural scientists and some ecological economists have placed a very heavy emphasis on the role of energy and its availability in the economic production and growth processes (Hall *et al.*, 2001, 2003). At the extreme, energy consumption rather than output of goods is used as an indicator of the state of economic development (Kardashev, 1964). According to Stern (1999), proponents of the Biophysical Theory of Economic Growth show that energy is indeed the only primary factor. They rest their opinion on the premise that there is a given stock of energy that is degraded (but due to the law of conservation not used up) in the process of providing services to the economy. This means that the energy available in each period needs to be exogenously determined (Stern, 1999). In this theory, capital and labour services rather than as stocks. Theses flows are computed in terms of the embodied energy consumed associated with them and the entire value added in the economy is regarded as the rent accruing to the energy used in the economy (Costanza, 1980; Hall *et al*, 1986; Gever *et al*, 1986; Kaufmann, 1987). Although the Classical Theory of Economic Growth did not explicitly recognize energy as a factor of production, they understood clearly the limit that land imposes on economic activities, especially in agriculture. They implicitly incorporated energy into the economy by recognizing land as a factor of production in agriculture (Brue, 2000). The Neutrality Hypothesis (Yu and Choi, 1985) posits that energy plays a minimal or neutral role in economic growth. The Ecological Economics Approach (Georgescu-Roegen, 1971; Costanza, 1980; Cleveland *et al*., 1984; Hall *et al*., 1986, 2001, 2003; Ayres and Warr, 2005, 2009; Murphy and Hall, 2010) and the Mainstream Economic Theory which usually thinks of capital, labour and land as the primary factors of production, while goods such as fuels and other sources of energy as the intermediate inputs (Aghion and Howitt, 2009). However, the literature adopted by this study is one that unifies the model of energy/electricity and growth, which is basically a synthesis of the mainstream economic growth theory and the growth theory of ecological economics. The rationale behind this selection is partly due to the fact that thermodynamics implies that energy/electricity is essential to all economic production thereby supporting the criticism levelled against mainstream economic growth models that ignore energy is legitimate. On the other hand, theories that try to explain growth entirely as a function of energy/electricity supply, while ignoring the roles of information, knowledge, and institutions, are also incomplete. Besides, institutions also affect how these roles play out and, therefore, the mainstream theory of economic growth, which focuses on these considerations. A significant part of the ecological economics contribution is the critique of mainstream theory.

Most of the studies carried out on this subject matter has left researchers with mixed results as the direction of unidirectional causality varies from country to country. Some studies such as Kouakou (2010), Gurgul and Lach (2011), Bildirici and Kayıkcı (2012), Hu and Lin (2013), Ogundipe and Apata (2013) and Nazlioglu *et al*. (2014) found that there was bidirectional causality between electricity consumption and economic growth. Other studies such as Shiu and Lam (2004), Altinay and Karagöl (2005) and Atif and Siddiqi (2010) have found that there was unidirectional causality from electricity consumption to economic growth, while some studies such as Ozun and Cifter (2007), Ciarreta and Zarraga (2007), Hye and Riaz (2008), Adom (2011) and Akinwale *et al*. (2013) have found that there was unidirectional causality from economic growth to electricity consumption. Relatively few studies such as Yu and Hwang (1984), Ciarreta and Zarraga (2007) and Aktaş and Yılmaz (2008) have reached there were no causality between electricity consumption and economic growth. The general objective of this study is to find out the nature of causal relationship between electricity consumption and economic growth in the Nigerian context. This objective would be pursued in line with the synthesis of the mainstream and ecological economic models of economic growth which will inform the choice of control variables such as labour force and capital formation.

## Methodology and Data

### (A)The Model

Theoretically (mainstream economic theory and ecologicalo economic models), Electricity consumption and the Economic Growth affect each other. The nature of this relationship controlled for labour force and capital formation however is best expressed in a system equation. Generally, every simultaneous equation is a system equation and every system equation is not a simultaneous equation. In other words, simultaneous equations are subsets of system equations. A system equation becomes a simultaneous equation when there exists simultaneity problem in the system. If there exist Simultaneity Bias in the system, the Ordinary Least Square estimates fails and loses its BLUE (Best Linear Unbiased and Efficient Estimates) properties and becomes inconsistent and inefficient. Therefore system equations estimations techniques like Limited Information Maximum Likelihood (LIML), Full Information Maximum Likelihood (FIML), Mixed Equation Estimation (MEM), Three Stage Least Squares (3sls), Two Stage Least Squares (2sls), Reduced Form Method (Indirect Least Squares), or Instrumental Variable (IV) estimation techniques are adopted depending on the simultaneous equations' identification state. In the absence of Simultaneity Bias, the Ordinary Least Square (OLS) estimates still maintains their BLUE property. It is important to note that Vector Auto-Regressive (VAR) model estimation adopts the BLUE regression properties of Ordinary Least Square (OLS). Therefore, in the absence of Simultaneity Bias, the Vector Auto-Regressive (VAR) model estimation will be adopted. The augmented vector auto-regression (VAR) process of order k is given as;

$$Y_t = \sum_{i=1}^{k} \varphi_i Y_t - \varepsilon_{1t} \ldots\ldots\ldots\ldots\ldots (1)$$

Where $Y_t$ is an L x 1 vector of innovations, and $\varphi_i$ {i = 1, 2, ..., k}. In this case, L = 4 and$Y_t$= {RGDP, EC} where each variable denotes real gross domestic product (RGDP) and energy consumption (EC) respectively. Equation (1) can be re-written to capture individual equations in accordance with the synthesis of the mainstream and ecological economic models of economic growth. The choice of the functional form of a regression model can be empirically inferred by the Box-Cox estimation or the Mackinnon, White, and Davidson (MWD) estimation test. Adopting the six-step Mackinnon, White, and Davidson (MWD) test with the null hypothesis of a level-level model and Double-log model as the alternative hypothesis, the functional form of this model will be justified. In line with this theory, the variables of interest include real gross domestic product (RGDP), electricity, controlled for capital formation (CF) and labour force (LF) as proposed by the mainstream economic theories. The model containing these models in matrix form is given thus:-

$$A = \beta' X + \mu$$

$$\boldsymbol{A} = \begin{bmatrix} \varphi_{+i} \\ \omega_{+i} \\ \aleph_{+i} \\ \beth_{+i} \end{bmatrix}, \quad \boldsymbol{\beta}' = [\propto_r \boldsymbol{\theta}_{ri} \boldsymbol{\beta}_{ri} \boldsymbol{\gamma}_{ri} \boldsymbol{\delta}_{ri}], \quad \boldsymbol{\mu} = \begin{bmatrix} \varepsilon_{rt} \\ \varepsilon_{rt} \\ \varepsilon_{rt} \\ \varepsilon_{rt} \end{bmatrix},$$

$$and$$

$$\boldsymbol{X} = \begin{bmatrix} \mathbf{1} & \mathbf{1} & \mathbf{1} & \mathbf{1} \\ \sum_{i=1}^{m} \varphi & \sum_{i=1}^{m} \varphi & \sum_{i=1}^{m} \varphi & \sum_{i=1}^{m} \varphi \\ \sum_{i=1}^{m} \omega & \sum_{i=1}^{m} \omega & \sum_{i=1}^{m} \omega & \sum_{i=1}^{m} \omega \\ \sum_{i=1}^{m} \aleph & \sum_{i=1}^{m} \aleph & \sum_{i=1}^{m} \aleph & \sum_{i=1}^{m} \aleph \\ \sum_{i=1}^{m} \beth & \sum_{i=1}^{m} \beth & \sum_{i=1}^{m} \beth & \sum_{i=1}^{m} \beth \end{bmatrix}$$

$L_nRGDP_{t-i} = \varphi(Phi)$, $L_nEC_{t-i} = \omega(Omega)$, $L_nCF_{t-i} = \aleph(Alef)$, and $L_nLF_{t-i} = \beth(Bet)$. Where $r = column\ number$
Expanding the matrices above and substituting the notational symbols to its variable terms will produce equations two, three, four, and five. These equations are shown below:

Where:

RGDP =Real Gross Domestic Product
EC =Electricity Consumption
CF =Capital Formation
LF =Labour Force
$L_n$ =Logarithmic form values
Δ = first difference operator
$\propto, \theta, \gamma, \delta$ are parameters to be estimated and $\varepsilon$ represents the serially uncorrelated error terms.

**(B)Unit Root Tests**

Stationarity of variables implies that the mean and standard deviations does not change with time. The tests are used to investigate whether the mean value and variance of the stochastic process are constant over time. To do this we test the order of integration of the individual series under consideration. The procedure adopted are the Augmented Dickey-Fuller (ADF) test due to Dickey and Fuller (1979, 1981) and Zivot-Andrews (1992). Augmented Dickey-Fuller test and Zivot-Andrews rely on rejecting a null hypothesis of unit root (the series are non-stationary) in favour of the alternative hypothesis of stationarity. The tests are conducted for each of the time series variables.

The general form of ADF test is estimated by the following regression:

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \sum_{i=1}^{n} \alpha_i \Delta Y_{t-i} + \varepsilon_t \ \ldots \quad (6)$$

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{n} \alpha_i \Delta Y_{t-i} + \varepsilon_t \ \ldots . \ (7)$$

Where Y is time series variable under study, t is a linear time trend, Δ is the first difference operator, $\beta_1$ is the constant, n is the optimum number of lags in the dependent variable, Σ is the summation sign, and $\varepsilon_t$ is a pure white noise error term.

Note: Models (6) and (7) are general form of ADF tests with intercept, and trend and intercept respectively.

In practical terms, since as we are dealing with time series variables which are generated through a stochastic process (that is, a collection of random variables ordered in time), we are to determine first if this stochastic process is stationary. For this purpose, the Augmented Dickey-Fuller (ADF) test is used. A variable is stationary if the absolute ADF value (|τ|) is greater than any of the absolute Mackinnon tau critical values.

The Augmented Dickey Fuller (ADF) test was applied to find the existence of unit root in each of the time series.

Hypothesis testing:

$H_0$: $y_t$=0
$H_1$: $y_t$<0

Decision Rule: reject the null hypothesis if $|\tau_{cal}| > |\tau_{tab}|$, do not reject if otherwise. If the null hypothesis is rejected, it means the series are stationary or integrated or order one, which is I (1).

**(C)Co-integration Test**

Co-integration analysis helps to clarify the long-run relationships between integrated variables. Johansen's (1999, 1991) procedure is the maximum likelihood for the finite-order vector auto-regressions (VARS) and is easily calculated for such systems, so it will be used in this study. The Johansen technique was chosen not only because it is VAR-based but also because it performs better than single-equation and alternative multivariate methods (Lutkepohl, 2001).

The trace test and the maximum Eigen-value method will be used to test for r (the maximum number of co-integrating relationships).

The trace statistic is given as:-

$$\lambda_{trace} = \sum_{n-t+1}^{k} \ln(I - \lambda_j)^{-T} \qquad \ldots . (8)$$

Where T is the number of time period observations and $\lambda_j$ is the *i*th largest eigen value. The null hypothesis is that the co-integrating rank is r and the VAR process. It is pertinent to mention that before performing the Johansen co-integration test, this study will use the Akaike's Information Criterion (AIC) and the Hannan-Quinn Information Criterion (HQIC) to determine the optimum lag length. The number of co-integrating vectors is denoted by $r_0$; the trace test is calculated under the null hypothesis:

$H_0$: $r_0 \leq r$
$H_1$: $r_0 = r$

**Decision Rule**: reject the null hypothesis if $|\tau_{cal}| > |\tau_{tab}|$ at the level of significance, do not reject if otherwise.

**(D)Causality Tests**

In analysing Granger-Causality relationships, our main interest is to find the lead/lag relationship between variables. The Granger (1969) approach to the question of whether X causes Y is to determine how much of the current Y can be explained by past values of Y, and then to see whether adding lagged values of X can improve the explanation. Y is said to be Granger-caused by X if X helps in the prediction of Y, or if the coefficients on the lagged Xs are statistically significant. Note that two-way causation is frequently the case: where X Granger-causes Y and Y Granger-causes X). But in this research work, the researchers shall be looking at a case of Granger-causality that entails five (5) endogenous variables namely real gross domestic product (RGDP), electricity consumption (EC), capital formation (CF) and labour force (LF).It is important to note that the statement "X Granger-causes Y" does not imply that Y is the effect or the result of X. Granger-causality measure precedence and information content but does not of itself indicate causality in the more common use of the term.It is better to use more than fewer lags in the test regressions, since the Granger approach is couched in terms of the relevance of all past information. It is necessary to pick a lag length, one that corresponds to reasonable beliefs about the longest time over which one variable could help predict the other.

The following equations are used to determine the causality:

$$\Delta Y_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta Y_{t-} + \sum_{i=1}^{m} \gamma_i \Delta X_{t-i} + \mu \quad \ldots \quad (9)$$

$$\Delta X_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta X_{t-i} + \sum_{i=1}^{m} \Psi \Delta Y_{t-1} + \mu \quad \ldots \quad (10)$$

Where $Y_t$ and $X_t$ are defined as Y and X observed over time periods; Δ is the difference operator; m represents the numbers of lags; α, β, ψ and γ are parameters to be estimated; and μ represents the serially uncorrelated error terms. The test is based on the following hypotheses:-

$H_0$: $\gamma_i = \psi = 0$ for all i's
$H_1$: $\gamma_i \neq 0$ and $\psi \neq 0$ for at least some i's.

At this point, it is necessary to examine the criteria for causality. The hypothesis would be tested by using chi-square ($\chi^2$) statistics. If the values of the $\gamma_i$ coefficient are statistically significant but those of the ψ are not, then X causes Y (X→Y). On the contrary, if the values of the coefficients are statistically significant but those of the coefficient are not, then Y causes X (Y→X). If both are significant, then there exists bidirectional causality between X and Y (X⇄Y) otherwise, we have a case of independence or no causal relationship between X and Y (X⇎Y).

**(E)Stability Test**

The stability test will be carried out to show if the model invoked is stable to allow for forecasting. For a set of n time series variables $y_t = (y_{1t}, y_{2t,}, \ldots, y_{nt})'$, a VAR model of order p [VAR(p)] can be written as:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + u_t \quad \ldots(11)$$

Where the $A_i$'s are (nXn) coefficient matrices and $u_t = (u_{1t}, u_{2t}, \ldots, u_{nt})'$ is an unobservable zero mean error term. In accordance with the above identity, the stability of a VAR can be examined by calculating the roots of:

$$(I_n - A_1 L - A_2 L^2 - \ldots.) y_t = A(L) y_t \ldots(12)$$

The characteristic polynomial is defined as:

$$\Pi(z) = (I_n - A_1 z - A_2 z^2 - \ldots.) \ldots(13)$$

The roots of $|\Pi(z)| = 0$ will give the necessary information about the stationarity or non-stationarity of the process.The necessary and sufficient condition for stability is that all characteristic roots lie outside the unit circle. Then Π is of full rank and all variables are stationary.

**(F)The Impulse Response Function**

VAR models are difficult to interpret. One solution is to construct an impulse response function (IRF). The IRF traces the response of the endogenous variables to one-standard deviation shock to one of the disturbance term in the system. This shock is transmitted to all of the endogenous variables through the dynamic structure of the VEC models (Lutkepohl, 2001). We can express the equation (1) in a vector moving average (MA) form such as

$$Y_t = \sum_{i=0}^{\infty} A_i \Sigma_{t-1} + \sum_{i=0}^{\infty} G_i D_i \quad \ldots(14)$$

Where the L x I coefficient matrices Ai can be obtained using the following recursive relationships:

$$A_i = \varphi_1 A_{i-1} + = \varphi_2 A_{i-1} + \ldots + \varphi_k A_{i-k} \quad t = 1, 2, \ldots, i \ldots(15)$$

with $A_0 = I_r$ and $A_i = 0$ for i < 0 and $G_t = A_i \Psi$, where previous definitions hold and $1_t$ is the identity matrix of dimension 1.

**(G)Sources of Data**

The study employed annual secondary data from 1980 to 2014. The short period covered is as a result of the unavailability of data. The variables of interest include real gross domestic product (RGDP), electricity consumption, capital formation (CF) and labour force (LF) as proposed by the mainstream economic theories. All variables used are in natural logarithms. Data for electricity consumption were extracted from International Energy Agency (IEA) while the data for real gross domestic product (RGDP), gross fixed capital formation were extracted from Central Bank of Nigeria (**C**BN) Statistical bulletin. The data on labour force was computed by the authors using Population and Unemployment figures gotten from National Bureau of Statistics (NBS) database.

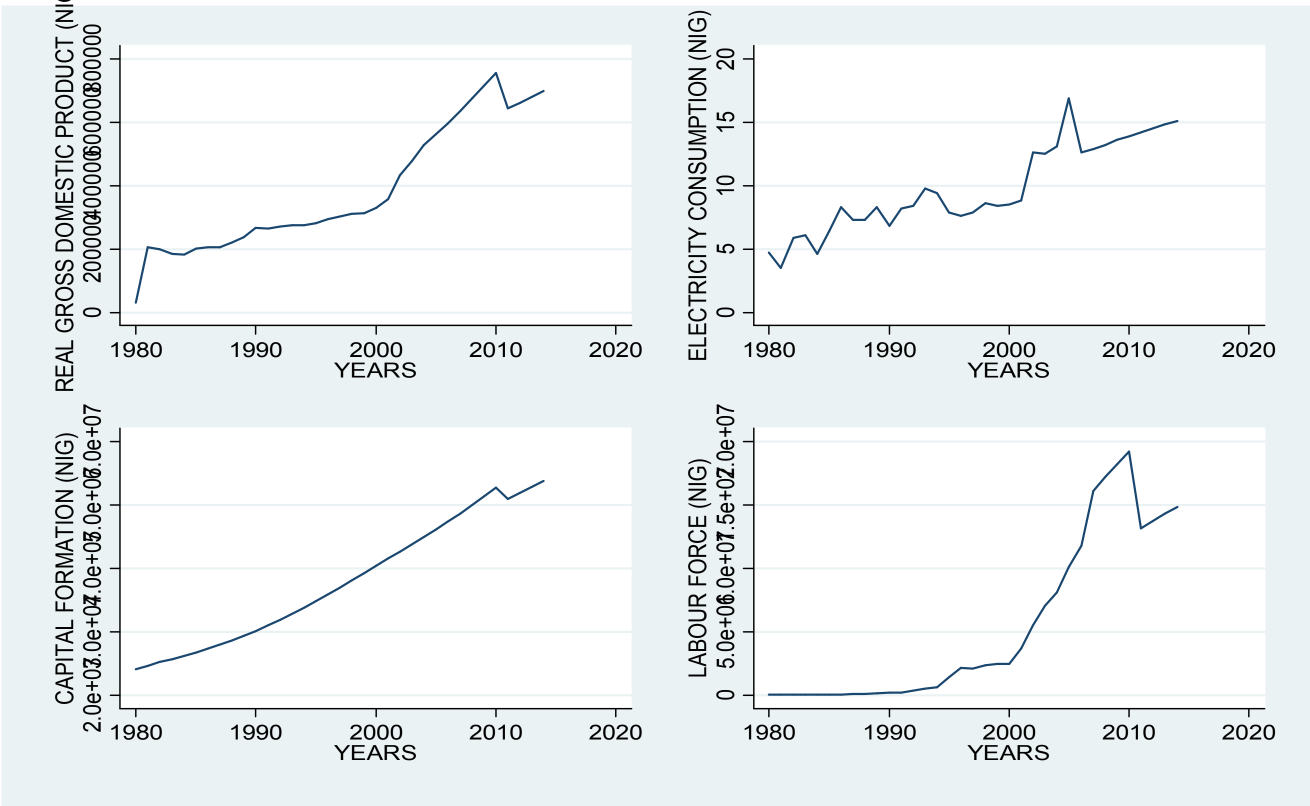
## EMPIRICAL RESULTS

**(A)Univariate Descriptive Statistics**

The summary statistics for the empirical analysis are below. The mean and standard deviation values of electricity consumption are 9.7886kwh and 3.486 respectively. The economic growth proxy by RGDP has the mean and standard deviation values of 384979 billion and 199513.9 respectively. More so, the mean and standard deviation values of capital formation are given as 37.978 trillion and 9835370 respectively, while that of labour force are 53.81million and 6548452 respectively. The figures below depict the graphical illustration of the data used for the analysis. The figures show that real gross domestic product and consumption of electricity witnessed significant fluctuation between 1980 and 2014. In addition, other series such as capital formation and labour have been fluctuating over time as well.

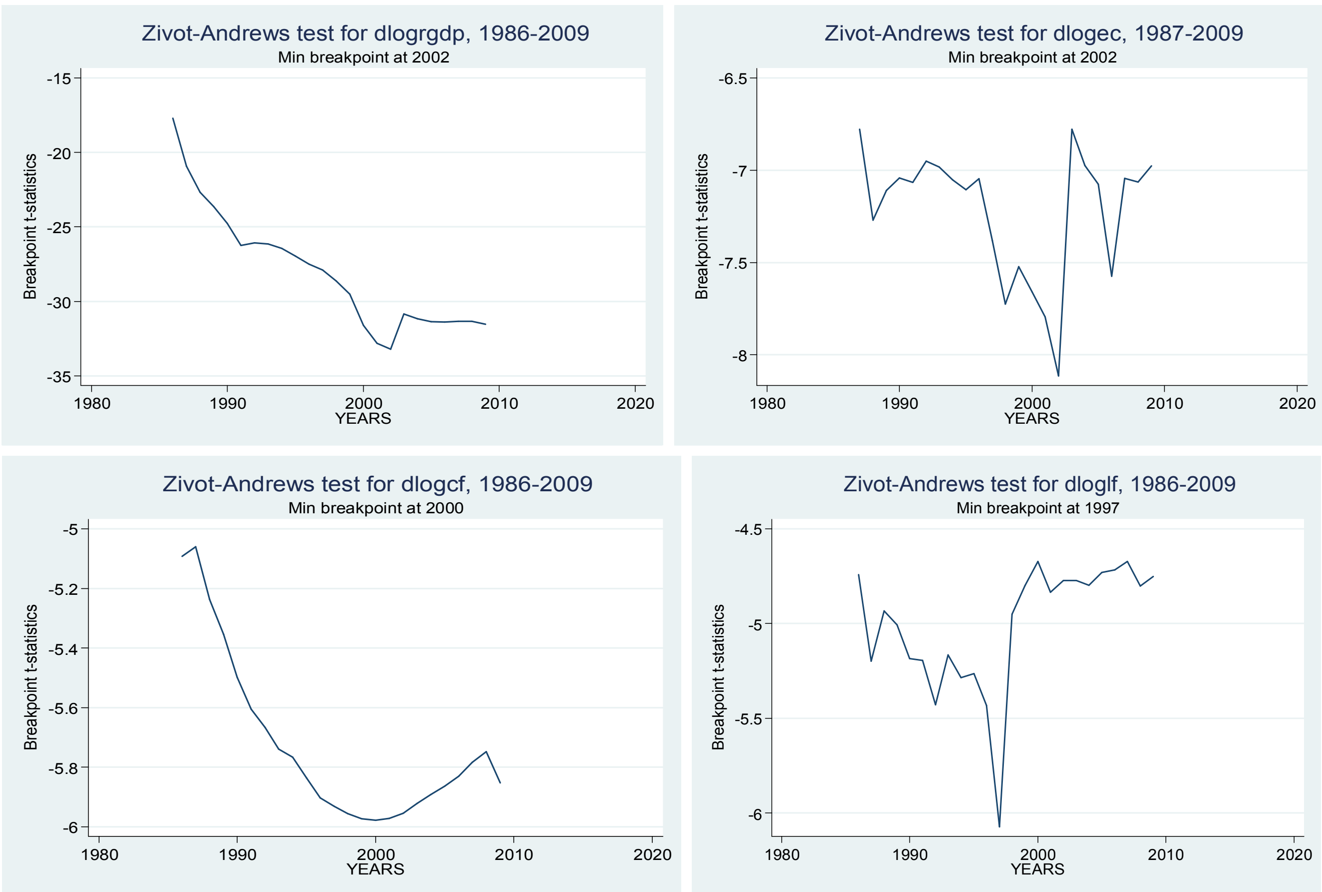
**(B)Unit Root Tests**

In this study, an Augmented Dickey Fuller (ADF) test was performed on Ln (RGDP), Ln (EC), Ln (CF), and Ln (LF). In all cases, a constant and a linear trend were included since this represents the most general specification.




**Source:** Researchers' Estimation using Stata 12.

**Figure 2. Trend of the variables of Interest**




**Source:** Researchers' Estimation using Stata 12.

**Figure 3. Zivot-Andrews Unit-Root Test Plots**

**Table 2. Unit Root Test for Stationarity (ADF)**

| Variables | ADF (Intercept and Trend) | Order of Integration |
|---|---|---|
| Ln (RGDP) | -4.4821 (-3.689)* | I (0) |
| Ln (EC) | -8.351 (-3.696)* | I (1) |
| Ln (CF) | -4.699 (-3.696)* | I (1) |
| | -4.029 (-3.696)* | I (1) |

**Source:** Researchers' Estimation using Stata 12.

**Table 3. Unit Root Test for Stationarity (Z-A)**

| Variables | Zivot-Andrews (Intercept and Trend) | Order of Integration |
|---|---|---|
| Ln (RGDP) | -33.217 (-5.57)* | I (1) |
| Ln (EC) | -8.114 (-5.57)* | I (1) |
| Ln (CF) | -5.978 (-5.57)* | I (1) |
| Ln (LF) | -6.073 (-5.57)* | I (1) |

**Source:** Researchers' Estimation using Stata 12.
**Note:-** * denotes significance at 1%. Figures within parenthesis indicate Mackinnon |τ| critical values. Mackinnon (1991) critical value for rejection of hypothesis of unit root applied.

The above results in Table 2 show that all the variables were not stationary at levels except Real Gross Domestic Product (RGDP) which was stationary at 1%, 5% and 10% levels of significance. This can be seen as stated before by comparing the observed values (in absolute terms) of the ADF with the critical values (also in absolute terms) of the test statistics at the 1%, 5% and 10% level of significance (what was recorded was only 1% significance level). Result from the table provides evidence of non-stationarity at levels of Ln (EC), Ln (CF), and Ln (LF). All the variables were differenced once except Ln (RGDP) and the ADF was conducted on them. Thus, they all became significant statistically and the results are however shown in the table. This however justifies a test of co-integration.

Moreover, from the Zivot-Andrews Test of stationarity, including breaks both in trend and intercept, all the variables were found to be stationary at first difference. This is inferred from the fact that the minimum T-statistics of the Zivot-Andrews Test for all the variables were all found to be greater than the critical value at 1%, thereby, leading to the rejection of the null hypothesis of unitroot. Observing breaks in trend and intercept, Zivot-Andrews computed the T-statistics using minimum of five years breaks from the beginning and end of the time series. The series employed in this work spans from 1980 to 2014. However, Zivot-Andrews T-statistics with breaks uses the minimum series of 1986 to 2009 and hence specifies the break point minimum statistics at 2002, 2002, 2000, and 1997 for Ln (RGDP), Ln (EC), Ln (CF), and Ln (LF) respectively. The chart below shows the break point statistics (including the minimums) on the Y-axis and then periods (year) on the X-axis for all the variables at their differenced logarithmic forms.

### (C)CO-integration test

Since the results of the unit root test above confirm stationarity of the variables at first difference with the exception of RGDP which is stationary at level form, the Johansen methodologies can then be apply in testing for co-integration (Johansen, 1988, 1991, 1992; and Johansen and Juselius, 1990). According to the procedure, the lag length of the VAR which must be small enough to allow estimation and high enough to ensure that errors are approximately white noise must be determined. Using three (3) different information criteria: Akaike Information Criterion (AIC), Schwarz Bayesian Information Criterion (SBIC), and the Hannan-Quinn Information Criterion (HQ), the researcher concluded that the optimal lag length for the variables (RGDP, EC, CF and LF) is one (1) as shown below:-

**Table 4. Lag Selection-Order Criteria**

| LAG | AIC | HQIC | SBIC |
|---|---|---|---|
| 0 | -2.4204 | -2.36008 | -2.23537 |
| 1 | -11.1637* | -10.8622* | -10.2386* |
| 2 | -10.9538 | -10.4109 | -9.28851 |

**Source:** Researcher's Estimation using Stata 10.

The uniformity of the conclusions from the Information Criteria in each of the lag length is worthy of note due to the sensitivity of the Johansen procedure to lag length selection. To determine the number of co-integrating vectors, the Trace test and the Maximum Eigenvalue test was be applied using the more recent values of MacKinon-haug-Michelis (1999). In this study, the number of co-integrating vectors was denoted by $r_0$; the trace test was calculated under the null hypothesis $H_0$: $r_0 \leq r$, and the alternative hypothesis, $H_0$: $r_0 \succ r$. The test results are presented in Table IV. If the test statistic is greater than the critical value at a given level of significance (5%), the null hypothesis will be rejected and vice versa. The result for this study is displayed below:-

**Table 5. Johansen Test for Cointegration**

| Rank test(trace) | Eigenvalue | Trace statistic | 5% critical value |
|---|---|---|---|
| 0 | 0 | 129.68 | 47.21 |
| 1 | 0.48266 | 36.4559 | 29.68 |
| 2 | 0.31592 | 13.133* | 15.41 |
| 3 | 0.20990 | 3.70 | 3.76 |

**Source:** Researchers' Estimation using Stata 12.
* denotes acceptance of the null hypothesis at the 0.05 percent Probability level

Since the $|\tau_{cal}|$ is less than the $|\tau_{tab}|$ at the 5% level of significance, the null hypothesis of one co-integrating vector will be accepted. Accordingly, economic growth, electricity consumption, capital formation and labour force are said to be co-integrated at 5% level of significance. As a result, there exist a long-run relationship between economic growth, electricity consumption, capital formation and labour force for Nigeria in the sample period.

### (D)Granger-causality tests

Given the rejection of the null hypothesis of the Mackinnon, White, and Davidson (MWD) test, the model is specified in its Log-Log model. More so, adopting the Hausman Specification test of Simultaneity Bias, the Null Hypothesis of no simultaneity bias was not rejected judging from the fact that the coefficient of the estimated residual of the reduced form model (with the intercept term on the right hand side) is statistically zero. Therefore, adopting the Vector Auto-Regressive (VAR) estimation techniques and thus, believing the estimates (estimators) from the VAR model estimation is BLUE. Considering the broad and basis objective of this research work, the full VAR-Granger Causality test was adopted. The results of Granger-causality between real GDP, electricity consumption, capital formation and labour force, as well as the computed f-values and their respective probabilities for the data of those series during the period 1980 – 2014 with specific lag period as calculated through the model of causality presented in section D is presented in Table IV below. To assess whether the null hypothesis would be accepted or rejected, a significance level of 5% was chosen. In line with the theory that synthesizes the mainstream and ecological economic models of economic growth, the variables of interest include real gross domestic product (RGDP) and electricity consumption (EC). Then there is capital formation (CF) and labour force (LF) as held by the mainstream economic theories.

**Table 6. Granger-Causality Tests**

| Granger causality tests | | | |
|---|---|---|---|
| | F Statistics | Lag | p-value |
| LNRGDP does not cause LNEC | 0.62107 | 2 | 0.431 |
| LNRGDP does not cause LNCF | 27.153 | 2 | 0.000 |
| LNRGDP does not cause LNLF | 4.2057 | 2 | 0.040 |
| LNEC does not cause LNRGDP | 17.045 | 2 | 0.000 |
| LNEC does not cause LNCF | 0 .7113 | 2 | 0.399 |
| LNEC does not cause LNLF | 0 .14414 | 2 | 0.704 |
| LNCF does not cause LNRGDP | 0 .01327 | 2 | 0.908 |
| LNCF does not cause LNEC | 0 .61217 | 2 | 0.434 |
| LNCF does not cause LNLF | 9.7077 | 2 | 0.002 |
| LNLF does not cause LNRGDP | 0 .08514 | 2 | 0.770 |
| LNLF does not cause LNEC | 4.8465 | 2 | 0.028 |
| LNLF does not cause LNCF | 4.0863 | 2 | 0.043 |

**Source:** Researchers' Estimation using Stata 12.

In terms of Real Gross Domestic Product, LNRGDP, the Granger-causality is not found to run from LNRGDP to LNEC. But, it runs from LNRGDP to LNCF and to LNLF. Thus, the null hypothesis of *LNRGDP does not Granger-cause LNCF, and LNLF* is rejected at the 5% level of significance as informed by the chi-square probability values. In terms of Electricity Consumption, LNEC, the Granger-causality is not found to run from LNEC to LNCF, and LNLF. But runs from LNEC to LNRGDP. Rejecting the null hypothesis of *LNEC does not Granger-cause LNRGDP* at the 5% level of significance as informed by the chi-square probability values.
In terms of capital formation, LNCF, the Granger-causality is not found to run from LNCF to LNRGDP, and LNEC. Causality then runs from LNCF to LNLF. The null hypothesis of *LNCF does not Granger-cause LNLF* is rejected at the 5% level of significance as informed by the chi-square probability values.

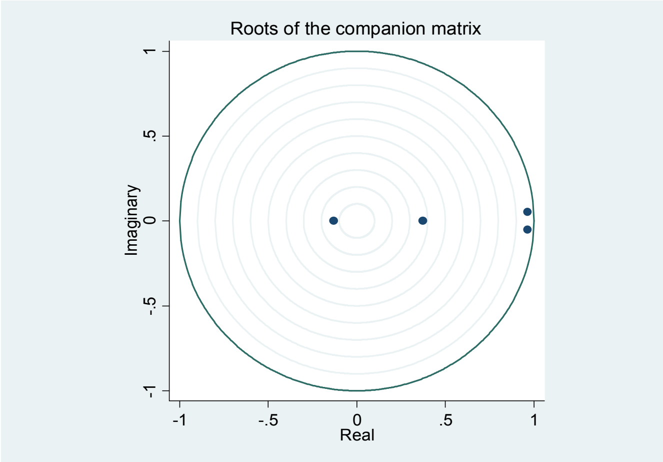
In terms of labour force, LNLF, the Granger-causality is not found to run from LNLF to LNRGDP. The null hypothesis of LNLF *does not Granger-cause LNCF and LNEC* is thus rejected at the 5% level of significance, as informed by the chi-square probability values.

In nutshell, the nature of causality amongst the variables are highlighted below. There exist a unidirectional causality from:

- Economic growth to capital formation
- Economic growth to labour force
- Electricity consumption to Economic growth and
- Labour force to Electricity consumption.
- However, there exist a bi-directional causality between
- Labour force and capital formation.

**(E)Stability test**

It is very important to carry out a stability test on a VAR model, especially when the model tested will be used for forecasting. Stability test helps to ascertain that the variables are identified and hence predictable. It is worthy to note that unidentified (unstable) models or equation cannot be estimated. Essentially, the necessary and sufficient condition for stability is that all characteristic roots lie outside the unit circle. In other words, using the Eigen-value stability condition, VAR satisfies stability condition if all the Eigenvalues lie inside the unit circle. The result obtained in this study is graphically presented as follows:-



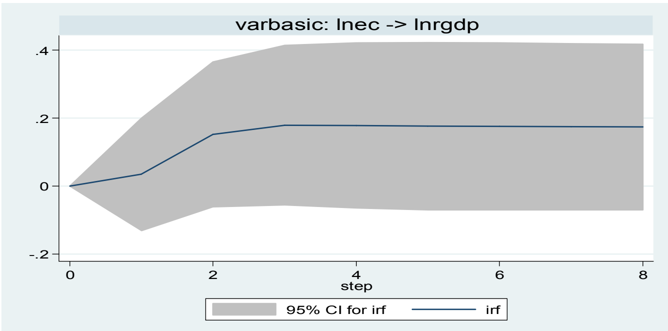

**Source:** Researcher's Estimation using Stata 12.

**Figure 4. Stability Test graph**

From the above diagram, it is evident that all the Eigenvalues lie inside the unit circle. Thus, VAR satisfies stability condition and any form of forecasting done with the model is reliable.

**(F)Impulse response function**

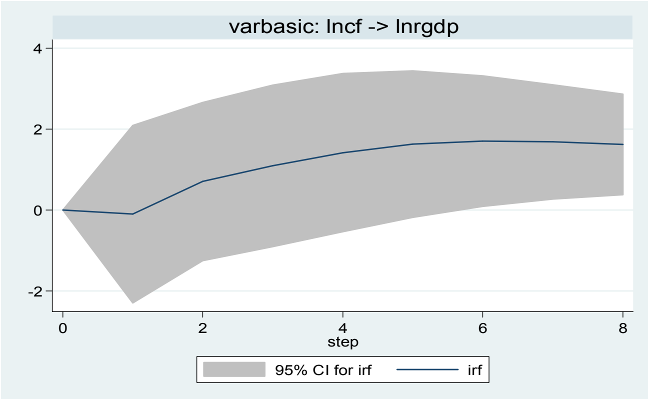
Impulse response functions show the effects of shocks on the adjustment path of the variables. Such shocks might include changes in oil prices, monetary policy, and nominal exchange rate, public expenditure on capital items or project and rise in unemployment. Its computation is useful in assessing how shocks to economic variables reverberate through a system.




**Source:** Researchers' Estimation using Stata 12.

**Figure 5. Response of REAL GDP to Electricity Consumption Shocks**

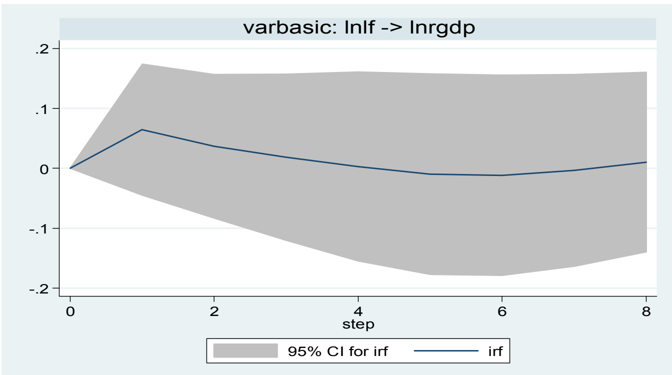
As the diagram above depicts, in the first period approximately, shocks in electricity consumption led to a fall in real GDP which hits its lowest point towards the end of the first period and started rising in the second period until it hit its trough in the third period approximately. Afterwards, real GDP did not respond to any further shocks as it evened out eventually around the fifth period. Factors which are likely to be responsible for the shocks in electricity consumption include fluctuations in the price of electricity through different managements, etc.




**Source:** Researchers' Estimation using Stata 12.

**Figure 6. Response of REAL GDP to Capital Formation Shocks**

As the diagram above depicts, in the first period approximately, shocks in capital formation will lead to a decrease in real GDP in the first period. Real GDP tends to rise subsequently in the preceding periods. This shows signs of switching into continues increasing real GDP beyond the third period. Factors that are responsible for fluctuations in capital formation entail the level of government expenditure on infrastructural facilities and capital items among others. Real GDP responds to fluctuations in capital formation because the Nigerian economy is still emerging in terms of infrastructure and any sign of increase or decrease in expenditure made on infrastructure will be reflected in the country's real GDP.




**Source:** Researchers' Estimation using Stata 12.

**Figure 7. Response of REAL GDP to Labour Force Shocks**

As the diagram above depicts, in the first period approximately, shocks in labour force will lead to an increase in real GDP in the first period. However, sign of a slight drop in real GDP began to show around the second period and this slightly continues even till the fifth period. At the sixth period approximately, real GDP seems to remain increase gradually and stabilizes around the eighth period. Factors responsible for fluctuations in labour force include the demography of the labour force, birth rate and death rate and so on. Real GDP responds to changes in labour force because the Nigerian economy is highly populated and still continues to stand as the most populous country in Africa. However, the productivity of the Nigerian labour force is usually not a true reflection of itself due to the high unemployment rate that exists in the country and the fact that dependency ratio of the Nigerian population is very high.

**Conclusions and Policy implications**

The study showed that electricity consumption is not only significant but contributes immensely to the growth of Nigerian economy both in the short and long run. It is also expected to show us the direction of investment to be followed by the government consequent upon the other variables introduced as justified by the synthesis of the mainstream and ecological economic models of economic growth. Given this findings, a pivotal recommendation that would be made is that there should be an increase in the daily generation of power so as to meet up with the increasing demand for power thus, rather than operating far below their capacities, more plant stations should be built and the alternatives to power supply by PHCN should be made more competitive so as to increase productions and the output of the economy as a whole.

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