Marcus, Samuel Nnamdi; Okezie, Amachukwu Chibuzo

Article

Testing the shock effect of some policy variables on electricity generation in Nigeria

International Journal of Energy Economics and Policy

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Marcus, Samuel Nnamdi/Okezie, Amachukwu Chibuzo (2017). Testing the shock effect of some policy variables on electricity generation in Nigeria. In: International Journal of Energy Economics and Policy 7 (3), S. 247 - 255.

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2017, 7(3), 247-255.

Testing the Shock Effect of Some Policy Variables on Electricity Generation in Nigeria

Samuel Nnamdi Marcus[1*], Amachukwu Chibuzo Okezie[2]

[1]Department of Economics, Achievers University, Owo, Nigeria, [2]Chartered Institute of Bankers Consultant, Lagos, Nigeria.
*Email: marcus2001ng2000@yahoo.com

ABSTRACT

Energy has been adjudged as the source of economic growth and wealth, the basis of economic and political controversy, technological inventions and innovations, and the basis of an epochal challenge global environment. This study examined the shock effect of some causative factors influencing electricity generation in Nigeria for 46 years beginning from 1970. The objective of the study is to investigate the effect of system shock on electricity generation in Nigeria. To achieve this, the study employed the impulse response function and variance error decomposition approaches through the vector error correction model. The study used the approaches to capture the impulse response of the variables and the variance error decomposition to obtain the reaction of the variables to errors committed in forecasting them. The study found no significant relationship between observed variables and electricity generation in the short run. There is a unidirectional causality running from electricity generation to economic growth, installed capacity and gas consumption and an independent causality between electricity generation, electricity consumption, price of electricity, and rainfall. The responds of electricity generation to shocks from other variables in the model are relatively low and sluggish. In forecasting electricity generation, error due to gas consumption is highest followed by error due to installed capacity of electricity. The study recommends the increase in electricity generation through increased installed capacity of electricity, electricity consumption, and price of electricity, economic activities, gas consumption and the construction of small hydro generating stations in all local government areas of the country.

Keywords: Electricity Generation, Vector Error Correction Mechanism, Hydro and Thermal Station
JEL Classification: Q4

1. INTRODUCTION

The provision of adequate, affordable, accessible and sustainable electricity supply is critical to the attainment of the broad goals of high and sustainable human development. Electricity interacts with human development at different levels. It helps facilitate economic development and poverty reduction by underpinning industrial growth and enhancing productivity. It contributes to social development by helping to fulfill the basic human needs of nutrition, warmth and lightning, in addition to education and public health (United Nations Development Programme, 2005 as cited in Presidential Advisory Committee 2006). Sanchis (2007) argued that increased electricity consumption will prevent the paralyzation of the industrial activity. The ability of a nation to develop its available resources and the attainment of economic development is linked to adequate generation and distribution of energy especially electricity. Hence, insufficient electricity supply has been identified as the major constraint to industrialization and economic development in Nigeria. Modern technologies used in design, production and delivery are electricity driven, hence, electric power supply is a basic infrastructure, requisite for industrialization. This brings to fore why adequate electricity use has taken center stage in every developmental discourse in Nigeria in the last two decades and half (1990's).

The quantity and quality of electricity consumed by consumers is a function of the quantity and quality, of it produced. Changes in household's lifestyles, technology import and increased productivity, and the growing commercial activities have increased the demand for electricity and are significant to induce electricity generation.

In Nigeria, consumers of electricity are conventionally classified into three major groups namely: Residential sector, commercial sector and street lighting, and industrial sector.

Energy literature in Nigeria show that most of the studies carried out on electricity is on consumption. Production of any commodity becomes important considering the fact that it precedes consumption as such there may not be consumption without production. A fall in production of electricity reduces its consumption by all economic units, hence a reduced standard of living of consumers.

Among the considered literature, only Sule (2010) and Emovon et al. (2010), and Ubi et al. (2012) focused on factors affecting electricity generation, problems of electricity generation and determinants of electricity supply in Nigeria respectively. These studies of Sule (2010) and Emovon et al (2010) were based on content analysis, hence, did not employ any econometric technique to establish short run relationship that exist among the identified variables. For instance, Sule (2010) identified non-diversification of energy sources, poor maintenance culture, transmission losses, kidnapping, the absence of research and development, competition, low level of annual rainfall as factors affecting generation, transmission and distribution of electricity in Nigeria.

Although the study is on electricity generation, distribution, and transmission, no distinction is made on how these factors identified affect the dependent variables neither did any relationship or interaction among the variables established. Emovon et al. (2010) made use of questionnaire to obtain problems of electricity generation to include; poor maintenance planning, inadequate funding, poor electricity pricing, monopoly poor energy mixing, inadequate gas supply, vandalization and drought were ranked according to the responses without the use of any statistical or econometric tool to establish the relationship and causality that exists among the variables. Although Osobase et al. (2014) employed an econometric technique ordinary least squares (OLS), the study only focused on causality and no long run and short run relationship between the variables is shown and the study is directed to study electricity supply and the manufacturing sector performance. The study of Ubi et al. (2012) also employed the OLS technique but not Vector error correction mechanism and did not include variables such as electricity installed capacity, electricity consumption, gas consumption, and economic growth in their model. Their study spans from 1970 to 2009. The objective of the study therefore is to examine the effect of shocks from policy variables on electricity generation in Nigeria from 1970 to 2015.

This study therefore, will employ appropriate econometric technique such as the impulse response and variance error decomposition approaches and ensure that robust diagnostic tests are carried out and cover the period spanning from 1970 to 2015; hence the most recent to the best of our knowledge on the causative factors influencing electricity generation in Nigeria.

2. LITERATURE REVIEW

2.1. Theoretical Framework

The Romer production function is aimed at explaining the long run growth by endogenizing productivity growth or technical progress with major assumptions among others as increasing returns to scale because of positive externalities. In its simplest form, the Romer production function for a firms is $Y = f(A, K, L)$. The AK model by Von Neumann is another simple endogenous growth model.

The assumption here is that A is a positive constant that reflects the level of technology which continues to grow and change giving research and development. Hence, there will be continuous growth as long as ideas flow in an economy. These ideas are non-rivalrous from skilled trained people and are translated into tools. Better tools allow production of more and high quality goods such as high yielding varieties of crops, cars, trains, medicine, TV, Phone Internet, planes, Rockets; cloning, computers.

The basis of neo-classical output growth theory is that it is possible to explain the patterns of economic change within a country, by making use of an aggregate production function. The aggregate production function relates the total output of an economy to the aggregate amounts of labor, human capital and physical capital in the economy, and some simple measure of the level of technology in the economy as a whole. According to this theory, production in each period begins with given amounts of capital, labor and technology, and terminates in the production of goods. This implies that increase in the inputs will increase output as well, and decrease in the inputs will also decrease output.

Lipsey (2001) observe that both neoclassical and endogenous growth models employ an aggregate production function, such as $Y = AL^{\beta} K^{\alpha}$, $\alpha+\beta = 1$.

Abramovitz (1956) as cited in (Scott et al., 2002) found that only 10 percent of output growth per person in the United States from 1869-78 to 1944-53 is associated with growth of factors of production, and 90 percent of output growth is associated with growth of total factor productivity (TFP). Solow (1957) (Scott et al., 2002) found that the accumulation of physical capital accounts for roughly 12% of output growth per hour worked in the United States from 1900 to 1949 with the remaining 88% attributed to growth of TFP. According to Easterly and Levine, (2001) TFP is often seen as the real driver of growth within an economy and studies reveal that whilst labor and capital are important contributors, Total Factor Productivity may account for up to 60% of growth within economies.

2.2. Empirical Issues

Empirical literature show that studies on electricity generation exists in Nigeria, other developing and developed countries. In Nigeria for instance, Sule (2010) studies major Factors affecting electricity generation, transmission and distribution in Nigeria employing a content analysis approach. Result reveal that factors identified include, the Niger Delta crisis which leads to the vandalization of oil and gas pipe lines, oil gas exploration and exploitation facilities, the kidnapping of foreign and indigenous professionals that manned oil and gas facilities in Nigeria resulting into abandoning of oil and gas exploration, the inability of Nigeria government in collaboration with oil multinational companies to utilize fully the gas, due to gas flaring, low level of annual rainfall in Nigeria due to global warming which leads to global climate change that affects water level at hydro generation stations.

Osueke and Ezeh (2011) examined Assessment of Nigeria power sub-sector and electricity generation projections. The study adopted model for analysis of energy demand (MAED) model for the energy supply strategy alternatives and their general environmental impact (MESSAGE) to forecast energy demand and supply from 2005 to 2030. Findings show that with 10% growth, demand for electricity will be 192000 MW while supply will be 276229 MW. The study further found that poor electricity supply in Nigeria to match the demand is due to poor generation of electricity from our power plants. Iwayemi (2008) investigated the issues and options of Investment in electricity generation and transmission in Nigeria using the content analysis method. Findings show that poor electricity service is the outcome of ageing and poorly maintained generating, transmission and distribution infrastructure facilities failures, weak financial and economic health of the state-owned company NEPA/PHCN.

Osobase et al. (2014) considered the nexus between electricity generation, supply and manufacturing sector performance in Nigeria employing Ordinary least square technique. A correlation result revealed a weak positive nexus between electricity generation and index of manufacturing production in Nigeria. The Granger Causality test showed a unidirectional causality between electricity generation and index of manufacturing sector production. Further test shows three co-integration equations at five percent level for the trace statistics, but no co-integration at five and one percent level for the Max-Eigen test.

Emovon et al. (2010) dwelt on Power Generation in Nigeria; problem and solution. The study adopted content analysis approach using questionnaire method. The result revealed that out of a total grid capacity of 8.876 MW only 3.653 MW was available as at December 2009. Thus available power is <41% of the total installed capacity. The result further shows that maintenance, planning and spare parts inventory, management as the most influencing factors affecting the effectiveness of the power generation system. Adenikinju (2008) using the content analysis method, found that competitive energy markets will play a major role in developing and deploying new technologies. Further, he asserts that strong competition in the electricity markets has a positive effect on the efficiency of power generation, because market players want to minimize their costs and invest in efficient technologies. We need to enhance the efficiencies of end-use technology.

Sambo et al. (2005) considered electricity generation and the present challenges in the Nigerian power sector using the MAED MESSAGE. Electricity supply is projected to be 28356 MW in 2015, 50817 MW in 2020, 77450 MW in 2025 and 136 879 MW in 2030 assuming the economy grows at 7%.

Essien et al. (2014) studied coal based generation as solution to Nigeria electricity problem adopting content analysis approach.

Findings from the study show that there is the need for the integration of clean coal power generation in the Nigeria electricity mix to reinforce its economic and social development and compete economically with the developed countries of the world. Udah (2010) studied industrial development, electricity crisis and economic performance in Nigeria. The result showed feedback causal relationship between GDP per capital and electricity supply. The result also showed no causal link in the case of industrial output and GDP per capita. George and Oseni (2012) investigated the relationship between electricity power and unemployment rates in Nigeria. The study established that the major cause of unemployment in Nigeria can be traced to inadequate and unstable power supply to industrial sector. Ugwu et al. (2012) in studying energy and economic losses due to constant power outages in Nigeria found that the economic losses associated with self-generation of electricity is high. Ubi and Effiom (2013) considered the dynamic analysis of electricity supply and economic development in Nigeria. Their result indicates that per capita GDP, lagged electricity supply, technology and capital are the significant variables that influence economic development in Nigeria. Furthermore, the outcome of the study reveals that despite the poor state of electricity supply, it influences economic growth in Nigerian though its impact is relatively very low. Ubi et al. (2012) in their study, the determinants of electricity supply in Nigeria found that technology, government funding, and the level of power loss were the statistically significant determinants of electricity supply in Nigeria and that an average of 40% of power is lost in transmission per annum. Uzoma et al. (2012) studied the role of energy mix in sustainable development of Nigeria using the OLS method. Empirical results indicate that existing energy mix has not significantly influenced sustainable development given that electricity generation is inadequate and coal is no longer in use. Results also show that per capita increase in oil consumption resulted in per capita increase in carbon emission and global warming.

Empirical literature from other developing countries also reveals that some studies have been carried in the area of electricity generation. Chinhao et al. (2015) investigated energy Flows from Primary Source to End Use in Malaysia. The results indicate that Malaysia's energy use depends heavily on fossil fuels, including oil, gas and coal. In the past 30 years, Malaysia has successfully diversified its energy structure by introducing more natural gas and coal into its power generation. Halil and Melik (2013) studied multivariate granger causality between electricity generation, exports, prices and economic growth in Turkey adopting ordinary least square technique using ARDL model. The first finding of the study is that there is a bidirectional Granger causality running from economic growth to electricity generation. This finding supports feedback hypotheses for Turkey. The manufacturing sector is a major consumer of electricity in Turkey. So, reducing electricity generation negatively affects economic growth. Also, an increase for the demand of electronic gadgets due to the increase in disposable income will result an increase for the electricity generation.

3. RESEARCH METHODS

This study is on electricity generation in Nigeria. This study employs the vector error correction model approach to study causative factors influencing electricity generation in Nigeria from 1970 to 2015. The vector error correction model is used to capture the short run dynamics and the impulse response as well as the granger causality of the variables in the model. Apart from the fact that this method has not been used to study causative factors of electricity generation in Nigeria earlier, the pre-test also supports its usage.

3.1. Model Specification

To investigate the causative factors influencing electricity generation in Nigeria, this study adapts the endogenous growth model. Prominent among these economists include Romer. In its simplest form, the Romer endogenous growth model is stated as follows:

$$Y = f(A, K, L) \quad (1)$$

Where,
Y = Total production
L = Labour input
K = Capital input
A = Total factor productivity.

Hence, an increase in either A, K or L will lead to an increase in output and vice versa.

This study adapts the work of Ubi et al. (2012) stated as follows:

$$ES = f(P, GF, RF, TECH, PWL) \quad (2)$$

Where,
ES = Electricity supply in megawatts hours
P = Price of electricity per megawatt in naira and kobo
GF = Government funding of electricity in Nigeria
RF = Quantity of rainfall per year in cubic centimeters
TECH = The state of technology (time variable, 1 year is one data point)
PWL = Quantity of electricity or power lost per year in megawatts.

This study adapts the above model on the assumption that supply of electricity is a function of generation of electricity. Hence, introducing variables of interest, we specify a functional relationship that;

$$Elg = f(Egr, Gas, Inc, Elc, Pre, Raf) \quad (3)$$

Where,
Elg = Electricity generated,
Egr = Economic growth,
Gas = Gas consumption,
Inc = Installed capacity,
Elc = Electricity consumed,
Pre = Price of electricity,
Raf = Annual rainfall.

This study therefore, replace government funding and state of technology with installed capacity of electricity on the assumption that installed capacity mirror the level of government funding of electricity generation and it also captures the state of technology in the power sub sector. The quantity of electricity lost is omitted on the assumption that no electricity is lost before generation.

The econometric and log form of equation (3) is as shown below;

$$\ln Elg_t = \psi_0 + \psi_1 \ln Egr_t + \psi_2 \ln Gas_t + \psi_3 \ln Inc_t + \psi_4 \ln Elc_t + \psi_5 \ln Pre_t + \psi_6 \ln Raf_t + \mu_t$$

The general form VECM is presented in equation 5 as follows:

$$\Delta N_t = \psi + \sum_{i=1}^{P=2} \lambda_t + \Delta N_{t-1} + \mu_t$$

Where;
In N_t is a vector of stationary variables in the system, ψ is a vector of constants, λ is the coefficients of the estimated variables, N_{t-1} is the number of lags, μ_t is the vector of error term. The expanded equation of the model is shown in equation 5.

$$\Delta \ln Elg_t = \psi_0 + \sum_{i=1}^{k} \vartheta_i \Delta \ln Elg_{t-1} + + \sum_{i=1}^{p} \zeta_i \Delta \ln Elc_{t-1} + \sum_{i=1}^{v} \varphi_i \Delta \ln Raf_{t-1} + \sum_{i=1}^{m} \lambda_i \Delta \ln Gas_{t-1} + \sum_{i=1}^{l} \theta_i \Delta \ln Egr_{t-1} + \sum_{i=1}^{n} \chi_i \Delta \ln Inc_{t-1} + \sum_{i=1}^{j} \gamma_i \Delta \ln Pre_{t-1} + \delta z_{t-1} + \tau_{t1}$$

3.2. Sources of Data

The study is of a time series type as such it utilizes secondary data. Electricity generation and consumption data were sourced from the 2007 Central bank statistical bulletin, 2014 power year review. Data for installed capacity of electricity for the study was obtained from the 2007 CBN statistical bulletin, 2010, 2011, 2012, 2013 and 2014 federal ministry of power annual review. The gross domestic and rainfall data were obtained from 2010 to 2014 CBN statistical bulletin while gas consumption was accessed from 2007, 2012 and trading economics.com. For price of electricity data electricity prices were obtained from the Nigeria Electrical Regulatory Commission February, 2001 and the report of the special committee on the review of petroleum supply and distribution; October, 2001 as cited in Ayodele and Folakun 2005 and multiyear tariff order of Nigerian Electricity Regulatory Commission 2012.

4. PRESENTATION OF RESULTS

Table 1 shows that all variables in the model except for gas consumption have unit process but are integrated of order one.

The lag order selection criteria on Table 2 that the appropriate lag length for this study is the two as indicated by the Akaike information criteria which is the lag selection criteria producing the minimum values among the competing lag length criteria.

The Table 3 reveals that that there are four co-integrating equations using both trace statistic and maximum Eigen value. This result confirms the use of vector error correction model. This is explained by the fact that the variables are co-integrated even though they have unit root process.

The VECM serial correlation test in Table 4 shows at that there is no serial correlation among the residuals of the model. This is revealed using the probability values higher than 0.05% from up to the 12th lags.

The VECM result presented above is estimated from equation 10 to precede the impulse response and the variance decomposition tests. It reveals that the variables in the model are insignificant in explaining changes in electricity generation in Nigeria within the period of the study. The error correction term is both correctly signed and significant. Also, the F-statistics confirms the collective significance of the variables in the models while the goodness of fit is also high (Table 5).

The impulse response function reveals the effects of shocks on the adjustment path of the variables in the model. Generally the IRFs show how variables in a model respond to different shocks in the model. The result as shown above reveals that electricity generation responded to own shock up to the tune of 9% but did not respond to innovation from any other variable. It further shows that own shock sluggishly led to less significant negative response on electricity output in 7, 9 and 10th periods (Table 6).

Electricity generation responded positively to innovations from economic growth and installed capacity of electricity throughout the ten periods with highest response to installed capacity in the ninth period. There were 7, 8, 9, and 10% shocks from gas consumption to electricity generation in the 6, 8, 9, and 10th periods respectively. Electricity most sluggish responds was on electricity price and rainfall. Responses to shocks from electricity price were mostly negative while its highest response to rainfall was 2%. Also very revealing is the response of electricity generation to shocks from electricity consumption. Responses here were all negative except in periods one and three (Table 7).

Table 7 presents the decomposition position of electricity generation in Nigeria from 1970 to 2015. The forecast error decomposition is the percentage of variance of the error made in forecasting a variable due to specific shock. It measures the contribution of each type of shock to the forecast error. It tells us how much of a change in a variable is due to its own shock and how much shocks due to other variables. Usually, for the initial period forecast error variance is due to own shock, however, as the lagged effects begin to manifest the percentage of the effect of other shocks increases over time.

Electricity own shock at the first was 100% as expected. In the second period the proportion due to shocks from other variables is 21.21% while own shock decreased to 13.47% in the 10th period. The result further reveals that proportion of variance due to shock of other variables in the model increased over time as expected. Error variance due to shocks from gas consumption, installed capacity and electricity consumption respectively are the most influential while Price of electricity however showed a low variance error.

Table 1: Unit root tests using augmented dickey fuller criterion

Variables	Levels	P value	First difference	P value	Critical value	Order of integration
lnElg	−2.687	0.084	−6.600	0.000	−2.929	I (1)
lnEgr	−2.392	0.149	−6.208	0.000	−2.933	I (1)
lnElc	−2.390	0.196	−9.240	0.000	−2.935	I (1)
lnInc	−1.991	0.289	−5.789	0.000	−2.929	I (1)
lnPre	−0.139	0.938	−6.969	0.000	−2.928	I (1)
lnGas	−3.728	0.007	-	-	−2.931	I (0)
lnRaf	−1.210	0.661	−9.994	0.000	−2.933	I (1)

Author regression output

Table 2: The VAR lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−40.889	NA	2.31e-08	2.280	2.570	2.387
1	154.553	316.429	2.23e-11	−4.693	−2.376*	−3.844*
2	208.417	69.254*	2.16e11*	−4.925*	−0.580	−3.332

*Indicates lag order selected by the criterion

Table 3: Johansen unrestricted rank (trace and Eigen maximum) co-integration test

Number of co-integrations	Trace statistic	Critical value	P value	Maximum Eigen value	Critical value	P value
None*	209.782	125.615	0.000	70.597	46.231	0.000
At most 1*	139.185	95.753	0.000	53.386	40.077	0.000
At most 2*	85.798	69.818	0.001	34.669	33.876	0.040
At most 3*	51.128	47.856	0.023	27.907	27.584	0.045
At most 4	23.221	29.797	0.235	13.318	21.131	0.423
At most 5	9.902	15.494	0.288	8.314	14.264	0.347
At most 6	1.587	3.841	0.207	1.587	3.841	0.207

Author regression output. *Indicates co-integration at 0.05 level of significance

The granger causality and block exogeneity test however shows no bidirectional causality from all the explanatory variables to electricity generation in Nigeria from 1970 to 2015. It however reveals a unidirectional causality from electricity generation to economic growth, installed capacity and gas consumption (Table 8).

4. 1. Analysis of Results

The short run dynamics reveal some interesting results with some variables conforming to our a' priori expectations and some at variance. Electricity generated in both periods as expected, affected electricity generation directly but insignificant in explaining changes in electricity generation in both periods. This suggests that the activities of the grid electricity suppliers in the past, increased generation in the current year. This could be attributed to some policy actions such as improved maintenance on the existing infrastructure, and procurement of new machines in the previous period whose lag effect is felt in the current period is it possible to give specific figures or estimates.

Increased economic activities in the short run directly affects electricity generation in the first period and indirectly in the second period though insignificant in both periods. The direct relationship is expected while we attribute the insignificance to the inability of firms to engage in activities that will increase electricity generation in the short run. It could also be that the electricity suppliers were unable to produce sufficient quantity of electricity to spur enough growth which in turn would increase generation of electricity.

Electricity consumed by users of electricity in both lags is inversely related to electricity generation and insignificant in explaining changes in electricity generation. This suggests that electricity consumption did not increase electricity generation instead decreased it. The situation confirms the Nigeria's electricity condition where peak demand is always higher than peak generation hence, increased consumption of electricity does not match with production. Reasons for the inverse relationship could be those that boarders around the inability of the supplies to expand its production capacity in the short run.

Gas consumption in the short run is inversely related and insignificant in explaining systemic change in electricity generation in both first and second lag. The study attributes this result to continuous breakings of the gas pipe lines in Nigeria over the years. This is substantiated with the fact that most generating stations in Nigeria are gas based (Federal Ministry of power Annual report and year book, 2012-2015).

Installed electricity capacity in the short run is inversely related to electricity generation in the second period and directly related in the first period. It is also insignificant in explaining systemic variations in it in both periods. The second period result is at variance with our expectation, but could be attributed to the inability of the stations to use these installations to capacity in the short run. Another reason is the fact that the installation and

Table 4: The VECM residual serial correlation LM test

Lags	LM-statistic	P
1	54.829	0.263
2	61.529	0.107
3	44.463	0.657
4	69.262	0.029
5	50.025	0.432
6	42.135	0.745
7	57.863	0.180
8	42.847	0.719
9	33.594	0.954
10	31.300	0.977
11	45.382	0.620
12	39.534	0.830

VECM: Vector error correction model. Authors regression output

Table 5: The VECM with electricity generation as dependent variable

Variables	Coefficients	Standard error	t-statistic
D(LNELG(−1))	−0.03	0.22	−0.13
D(LNELG(−2))	0.22	0.19	1.17
D(LNEGR(−1))	0.059	0.08	0.70
D(LNEGR(−2))	−0.01	0.08	−0.17
D(LNELC(−1))	−0.01	0.17	−0.06
D(LNELC(−2))	0.045	0.14	0.33
D(LNGAS(−1))	−0.16	0.11	−1.50
D(LNGAS(−2))	−0.099	0.08	−1.24
D(LNPRE(−1))	−0.023	0.05	−0.51
D(LNPRE(−2))	0.04	0.04	1.02
D(LNRAF(−1))	−0.25	0.23	−1.08
D(LNRAF(−2))	0.084	0.19	0.44
D(LNINC(−1))	0.46	0.19	2.39
D(LNINC(−2))	−0.12	0.21	−0.57
ECT	−0.43	0.19	−2.27
C	0.059	0.034	1.59
R^2	0.64		
Adjusted R^2	0.35		
F-statistic	2.21		

VECM: Vector error correction mechanism. Authors regression output

Table 6: The impulse response of electricity generation

Period	LNELG	LNEGR	LNELC	LNINC	LNGAS	LNPRE	LNRAF
1	0.09	0.00	0.00	0.00	0.00	0.00	0.00
2	0.04	0.02	−0.01	0.04	−0.02	−0.01	−0.00
3	0.04	0.00	0.01	0.00	0.04	0.01	0.01
4	0.01	0.03	−0.03	0.03	0.04	−0.01	−0.02
5	0.01	0.02	−0.03	0.04	0.05	−0.00	0.02
6	0.02	0.04	−0.03	0.05	0.07	−0.00	0.00
7	−0.00	0.03	−0.04	0.04	0.06	0.00	0.00
8	0.01	0.04	−0.05	0.04	0.08	−0.00	0.02
9	−0.02	0.04	−0.05	0.06	0.09	−0.01	0.01
10	−0.01	0.04	−0.05	0.04	0.10	0.00	0.02

Author regression output

Table 7: Variance decomposition of electricity generation

Period	SE	LNELG	LNEGR	LNELC	LNINC	LNGAS	LNPRE	LNRAF
1	0.09	100	0.00	0.00	0.00	0.00	0.00	0.00
2	0.11	78.79	3.19	0.53	14.93	2.15	0.32	0.083
3	0.13	72.14	2.62	1.20	11.70	10.52	0.94	0.89
4	0.14	55.77	5.34	6.84	13.13	15.10	1.41	2.41
5	0.16	43.12	5.44	8.86	15.83	22.09	1.08	3.58
6	0.19	31.97	7.39	9.51	17.65	30.09	0.80	2.58
7	0.21	26.09	8.68	11.99	17.18	33.29	0.66	2.11
8	0.24	20.27	8.96	14.26	16.03	37.63	0.51	2.36
9	0.27	16.31	9.11	15.12	17.08	39.81	0.44	2.13
10	0.30	13.47	9.08	15.80	15.88	43.18	0.36	2.23

Author regression output

Table 8: VEC granger causality/block Exogeneity Wald tests

Null hypotheses	Chi-square values	P	Remark
Egr→Elg	0.58	0.75	Reject
Elg→Egr	24.08	0.00	Accept
Elc→Elg	0.15	0.93	Reject
Elg→Elc	1.76	0.41	Reject
Inc→Elg	5.69	0.06	Reject
Elg→Inc	6.78	0.03	Accept
Gas→Elg	2.96	0.23	Reject
Elg→Gas	7.20	0.03	Accept
Pre→Elg	2.41	0.30	Reject
Elg→Pre	0.49	0.78	Reject
Raf→Elg	4.91	0.08	Reject
Elg→Raf	4.06	0.13	Reject

VECM: Vector error correction. Author regression output

eventual utilization of these stations takes time. So, even when new stations are being constructed, generation may decline until the stations are fully operational. Even when the stations are fully operational there are other factors that impede generation, such as low rain fall in the case of hydro stations and low gas supplies in the case of thermal stations, lack of trained personnel, sabotage etc.

In the short run, price of electricity is directly related with electricity generation but insignificant in the both periods. Increased price was insignificant given the fact that consumers level of compliance and reactions in the short run may not affect the revenue of the producers to cause major influence in electricity generation.

Increase in the amount of annual rainfall in the first period is inversely related with electricity generation, but directly related in the second period. A possible reason for this may be due to insufficient rainfall in the period and also for lack of maintenance and replacement of equipment in that period. It then holds that the second period may have witnessed sufficient rainfall and possible attention paid to the equipment.

The result further reveal that the speed of adjustment is 81.5% and significant at 0.05%t level of significant. The implication of this is that the model will return to its long run equilibrium in the following period at the speed of 81.5%. The relatively high speed of adjustment is a confirmation of the fact that many of the variables were significant in explaining systemic variation in electricity generation in Nigeria in the long run within the period of our study as well as the collective significance of the model in explaining changes in electricity generation. Also, revealed by the F-statistic and the R^2 is that 64% of variations in electricity generation is accounted for by electricity generation, economic growth, electricity consumption, installed capacity of electricity, gas consumption price of electricity, and annual rainfall.

The VEC granger causality/block exogeneity Wald tests show that there is no causality running from economic growth, electricity consumption, installed capacity of electricity, gas consumption, price of electricity and annual rainfall to electricity generation. This implies that these variables do not contain sufficient information to predict changes in electricity generation. However, the VEC granger Wald test reveal that that there a unidirectional causality from electricity generation to economic growth, installed capacity and gas consumption. This means that it is electricity generation that contains more information to predict changes in economic growth, installed capacity and gas consumption. Again, the unidirectional causality from electricity generation to economic growth can be likened to Osobase et al. (2014) unidirectional causality from electricity generation to manufacturing index.

The magnitude, positive or negative response of electricity generation to innovations from other variables is a function of policies and or activities on them. For instance, the positive responds to economic growth and installed capacity may have occurred in periods of high economic activities and the construction of generating stations. In the same vein, the negative response to gas consumption may have also occurred in periods of high gas line vandalization and vice versa. The sluggish responds to price of electricity is attributed to its status as a public utility for a long period of time and its nature as a necessity and normal product. The amount of rainfall, the number of hydro stations and their capacities are responsible for the sluggish responds of electricity generation to rainfall.

5. SUMMARY OF FINDINGS

The study provides result of the estimation of causative factors influencing electricity generation in Nigeria, employing annual data from 1970 to 2015. We employed the VECM technique to capture the short relationship among the variables, impulse response of the variables to own shocks as well as shocks from other variables and the variance error decomposition to obtain the amount of error made in forecasting due to innovations in the model. We also obtained the short run dynamics of our model. Relevant diagnostic tests such as the unit root test, serial correlation test, the bounds test, Johansen co-integration test, normality test, stability test, impulse response and variance error decomposition tests, the short run VEC Granger Causality/Block Exogeneity Wald Tests was carried out. All variables that entered the model were I (1) except for gas that was I (0).

The short run dynamics show that economic in the second period, electricity consumption in both periods, installed capacity in the second period, rain fall in the first period and gas consumption in both periods did not conform to our expectation. However, electricity generation in both periods, economic growth in the first period, price of electricity in both periods and rain fall in the first period are directly related with electricity generation. Again, electricity generation, economic growth, electricity consumption, installed capacity of electricity, price of electricity and rainfall were insignificant in explaining changes in electricity generation. Our model returns to its long run equilibrium at the speed of 81.5%. The most sluggish responds of electricity generation is to price of electricity and annual rainfall while its responds to economic growth and installed capacity is positive throughout the ten periods. There is a unidirectional causality running from electricity generation to economic growth, installed capacity and gas consumption and an independent causality between electricity generation, electricity consumption, price of electricity, and rainfall.

5. CONCLUSION

This study therefore, conclude that in economic activity, electricity consumption, installed capacity of electricity, gas consumption, price of electricity and rainfall are insignificant factors, explaining changes in electricity generated in the short run. We further conclude that in the short run economic growth in the second period, electricity consumption in both periods, installed capacity in the second period, rain fall in the first period and gas consumption in both periods did not conform to our expectation. However, electricity generation in both periods, economic growth in the first period, price of electricity in both periods and rain fall in the first period are directly related with electricity generation. Electricity generation, economic growth, electricity consumption, installed capacity of electricity, price of electricity and rainfall were insignificant in explaining changes in electricity generation. The variables excluded from the model are not significant in explaining changes in electricity generation in Nigeria within the period of our study. The responds of electricity generation to the other variables in the model are relatively low and sluggish. In forecasting electricity generation, error due to gas consumption is highest followed by error due to installed capacity of electricity. We also conclude that there is no causality running from the explanatory variable to electricity generation but a unidirectional causality from electricity generation to economic growth, installed capacity and gas consumption.

6. RECOMMENDATIONS

Electricity generation in Nigeria in the last 46 years has averaged 1689.3 MW with average installed capacity of 4531.9 MW giving an achievement rate of 37.3%. Both installed capacity and generation are however, too low for an economy that aspires to be among 20 top economies of the world in the 2020. Hence, considering the significance of the variables studied and focusing on our findings, this study recommend as follows:

1. Government should ensure the increase in installed capacity of electricity from the present 17,752 MW (consisting of existing and on-going construction) to 45,000 MW before the year 2020 as forecasted by energy commission of Nigeria. The multiplier effect of this will be an increased electricity generation from the present 1689.3-30,000 MW, since present peak demand is in the excess of 12,800 according to the Presidential task force on power in 2015.
2. Electricity consumption is an insignificant factor influencing electricity generation in Nigeria, electricity providers should enhance electricity consumption from the present 1154.2-20,000 MW considering the need for improved standard of living, increasing rate of population, increasing economic activity, and urbanization.
3. The Nigerian electricity regulation commission should considerably increase the price of electricity from the present average price of N8.38-N30 per kw. This will increase production, supply and demand given the cost and demand situations.
4. Government should remove and prevent any impediment to increasing in gas consumption. This will be achieved by the implementation of policies that will reduce gas line vandalization and gas flaring.
5. Increase in the construction of small units of hydro stations in each local government area of the country will make it significant, considering the fact that hydro is the dominant renewable energy source in Nigeria. This will reduce the reliance on heavy annual rainfall.

REFERENCES

Adenikinju, A. (2008), Efficiency of the energy sector and its impact on the competitiveness of the Nigerian economy. International Association for Energy Economics, 4, 27-31.

Chinhao, C., Weidou, N., Linwei, M., Pei, L., Zheng, L. (2015), The use of energy in Malaysia: Tracing energy flows from primary source to end use. Energies, 8, 2828-2866.

Easterly, W., Levine, R. (2001), It's not factor accumulation: Stylized facts and growth models. The World Bank Economic Review, 15(2), 177-219.

Emovon, I., Kareem, I., Adeyeri, M.K. (2010), Power Generation in Nigeria; Problem and Solution. Conference Paper. Nigerian Association of Energy Economists-Naee. Available from: http://www.org.ng/files/paper1pdf.

Essien, A.U., Igweonu, I.E., Eguzo, C.V., Robert, B.J. (2013), Integrating smart grid model in Nigeria power network. International Journal of Advances in Engineering and Technology, 6, 1760-1768.

George, E.O., Oseni, J.E. (2012), The relationship between electricity power and unemployment rate in Nigeria. Australian Journal of Business and Management Research, 22(4), 10-19.

Halil, A., Melike, K. (2013), Multivariate granger causality between electricity generation, exports, prices and economic growth in Turkey. International Journal of Energy Economics and Policy, 3, 41-51.

Iwayemi, A. (2008), Investment in Electricity Generation and Transmission in Nigeria: Issues and Options International Association for Energy

Economics. International Association for Energy Economics. p37-42.

Lipsey, R.G. (2001), What Does Total Factor Productivity Measure? Available from: http://www.csls.ca/ipm/1/lipsey-e.pdf.

Osobase, A.O., Bakare, A., Tunde, A. (2014), The nexus between electricity generation, supply and manufacturing sector performance in Nigeria. International Journal of Management Sciences and Humanities, 2(2), 184-204.

Osueke, C.O., Ezeh, C.T. (2011), Assessment of Nigeria power sub-sector and electricity generation projections. International Journal of Scientific and Engineering Research, 2(11), 1-7.

Presidential Advisory Committee. (2006), Twenty-Five Years Electricity Supply Projection. A Report on Nigeria's Electricity Sector.

Sambo, A.A., Garba, B., Zarma, I.H., Gaji, M.M. (2005), Electricity Generation and the Present Challenges in the Nigerian Power Sector. Abuja-Nigeria: Energy Commission of Nigeria.

Sanchis, M.T. (2007), Quantifying the Contribution of Electricity to Spanish Economic Growth During the Twentieth Century. Paper Presented at the 111 Iberometrics Valencia, March, 23-24.

Scott, L.B., Gerald, P.D.Jr., Robert, T. (2002), How Important Are Capital and Total Factor Productivity for Economic Growth. Working Paper; 2002. Available from: http://www.frbatlanta.org/filelegacydocs/wp0202a.pdf.

Sule, A.H. (2010), Major factors affecting electricity generation, transmission and distribution in Nigeria. International Journal of Engineering and Mathematical Intelligence, 1(1-3), 159-164.

Ubi, P.S., Effiom, L., Okon, E.O., Oduneka, A.E. (2012), The determinants of electricity supply in Nigeria. International Journal of Business Administration, 3(4), 72-82.

Ubi, P.S., Effiom, L. (2013), The dynamic analysis of electricity supply and economic development: Lessons from Nigeria. Journal of Sustainable Society, 2(1), 1-11.

Udah, E.B. (2010), Industrial development, electricity crisis and economic performance in Nigeria. European Journal of Economics, Finance and Administrative Sciences Issue, 18, 1-12.

Ugwu, H.U., Nwankwojike, B.N., Ogbonnaya, E.A., Ekoi, E.J. (2012), Energy and economic losses due constant power outages in Nigeria. Nigerian Journal of Technology (NIJOTECH),3(2), 183-187.

Uzoma, C.C., Nnaji, C.E., Nnaji, M. (2012), The role of energy mix in sustain able development of Nigeria. Continental Journal of Social Sciences, 5(1), 21-29.