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Power Sector Reforms and Electricity Supply Growth in Nigeria

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Abstract

Adequate power supply constitutes the nucleus of operations and subsequently the engine of growth for all sectors of the economy. Despite the abundance of electricity generation sources in Nigeria, electricity distribution network and voltage profile are very poor resulting to more that 50 percent of the populace living without electricity supply. To salvage the electricity problem, the power sector has gone through some reforms, the major one being the enactment of the Electric Power Sector Reform Act of 2005. This was intended to restructure the electricity market from monopoly to a more competitive structure. This study is therefore undertaken to empirically evaluate the impacts of the reforms on electricity supply growth in the country. This study is based on the elementary supply theory. It covers from 1981 to 2015. Econometric approach for the study relies on time series data regression. The study adopted the contemporary econometric approach of error correction mechanism (ECM). The results showed that all the variables were stationary and statistically significant. There exist a unique long-run equilibrium relationship between all the variables of the model and so, cointegrated and normalized coefficients were reported. ECM results revealed the speed of adjustment of 92.1 percent between the short-run and the long-run behaviors of electricity supply with its independent variables. From the analysis, reforms' coefficient (REF) had a positive sign but statistically insignificant. The other variables, electricity price (ELP), government investment in the power sector (GOVINV), annual rainfall (RAIN) and per capita GDP (PCGDP) conformed to apriori expectations in terms of sign and were statistically significant. The study concludes that the present reform efforts in the power sector will bring great improvements in the power sector of the country if properly harnessed. From the results, the study recommends that government should totally transfer ownership in all electricity production and supply chain to the private investors and only monitor or regulate the market.

Keywords: Electricity supply, Power sector, Reforms, Electricity market, Economic growth.

Contents

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1. Introduction

For a meaningful economic growth to take place in an economy there must be adequate supply and demand for energy. One of the most desired energy in this direction is electricity. Adequate generation, transmission and distribution of electricity will empower the people to work at home and the cottage industries through to large scale industrial, commercial and services activities. It constitutes the nucleus of operation and subsequently the engine of growth for all sectors of the economy (Ayodele, 2001; Ubi and Effiom, 2013).

Electricity is generated from primary energy sources such as solar, water, waves, wind, oil, gas, coal, tide, etc. Nigeria is well blessed with all these sources of energy. The country has an annual average daily sunshine of 6.25 hours, an average solar radiation of about 5.25 kilowatts/m^2/day and receives about 4.851 x 10^{12} kilowatts (kw) of energy per day from the sun (Odetunde, 2008; Solar Energy International, 2011). Proven crude oil reserves for the country as at 2013 is 37.2 billion barrels and proven natural gas reserve is 182 trillion cubic feet. Its coal reserve is estimated at 2 billion metric tonnes (Sambo *et al.*, 2010; United States Energy Information Administration (USEIA), 2013). The country is bounded on the South by Atlantic Ocean. Rivers Niger, Benue and many others traverse the country from North to South. There are many waterfalls, abundant wind, tides and waves.

Despite the abundance of electricity generation sources, Nigeria as reported by CIA (2014) has one of the lowest net electricity generation per capita rates in the world. Electricity distribution network and voltage profile are very poor resulting to more that 50 percent of the populace living without electricity supply (Osueke and Ezugwu, 2011). Electricity production and distribution system are weak and susceptible to major setbacks. The weak and inefficient system results from old and decaying infrastructure. Some of the electricity generation stations were built in the 1970s and are still being operated without major rehabilitations, retrofit or upgrade (Oyedepo, 2012). They are also poorly maintained. Also, until very recently, electricity generation, production and distribution has been an exclusive preserve of the poorly managed government monopoly under National Electric Power Authority (NEPA) and later Power Holdings Company of Nigeria (PHCN).

The inefficiency as well as inadequate facilities to boost electricity supply in the face of increasing population, new and electronic based technologies, vast geographical landscape and an increasing business environment all combines to create electricity supply problems. While demand for electricity is rising, supply tends to be falling. This supply inadequacy has damaging consequential impact on all sectors of the economy and therefore encourages the people to source for alternative, but unhealthy, electricity supply sources via the generators (small power generating sets). This situation generates additional costs to physical health (noise and air pollution) and businesses, leading to high prices, discouraging entrepreneurship, encouraging unemployment, elevating poverty and dampening industrial and economic growth.

To salvage the electricity problem in the country, the power sector has gone through some reforms recently. The major reform was set through the enactment of the Electric Power Sector Reform Act of 2005. This was intended to restructure the electricity market from monopoly to a more competitive structure, produce and supply more power and therefore enhance productive activities in the country. More than ten years has gone since the introduction of this reform agenda. As it is expected, the reform should transform the power sector and engender the needed improvements in the power sector. This study is therefore undertaken to empirically evaluate the power sector and examine the impacts of the reforms on electricity supply growth in the country.

1.1. Electricity Sector Reforms in Nigeria

Nigeria's electricity history dates back to 1896, fifteen years after it was introduced in England. A pioneer electric power generating plant with total capacity of 60 kw was installed at Marina in the present Lagos State. The Public Works Department (PWD) was in charge of its management. The Northern and Southern protectorate amalgamation of 1914 to form a new Nigeria created room for other towns to generate electric power for themselves. In 1946, the controlling powers of Public Works department over Lagos electricity generation and distribution was handed over to the Nigerian Government Electricity Undertaking (NGEU), who took over the responsibility for supplying electricity in Lagos as well as the assets and liabilities of the former operator. Electricity Corporation of Nigeria (ECN) came into being from 1950 and took over all electric power supply facilities within Nigeria. Meanwhile**,** Niger Dams Authority (NDA) also came into being and was inaugurated for the benefit of generating electricity through hydro power systems (Isola, 2012; Awosepe, 2014). This led to great improvement in power generation, transmission and supply in the country. With increasing demand for electricity, some projects were carried out in Ijora, Oji River, Kano and Ibadan power stations to improve availability and quality of power delivery (Isola, 2012; Awosepe, 2014).

In the year 1962, the Niger Dams Authority (NDA) was legally set up through an Act of Parliament. They were entrusted with dam construction after discovering the benefit that will accru**e** from such a project. This led to the construction of Kainji Dam in 1962 which was completed in 1968. The wide network of electricity transmission of grid power commenced from 1966 through the collaborative efforts of NDA and ECN. These efforts saw the linkage of different towns to the national grid and the extension of electricity power to all the regions that made up Nigeria. For instance, Lagos was linked to Kainji, Kainji was linked to Kaduna and extended to Kano and Zaria, Oshogbo was linked to Benin and Ugheli, Benin was linked to Onitsha and Afam. Despite the great size of Nigeria's land mass, the national grid now links the thirty-six state capitals and the Federal Capital Territory, Abuja. On "first of April 1972, ECN and NDA were merged to form the popular National Electric Power Authority (NEPA)"with the actual merging taking place on the sixth of January 1973 with the appointment of its first manager. The network continued to grow under NEPA and between 1978 and 1983, the Federal Government sponsored two panels of enquiry to fashion out models for restructuring NEPA into an independent unit or toward privatization. This empowered it to supply power to rural areas and new cities (Isola, 2012; Awosepe, 2014).

By 1999-2005 (the advent of democratic government), an Act was enacted establishing Power Holding Company of Nigeria (PHCN), an Initial Holding Company (IHC), as a result of Government effort to revitalize the power sector. This was an intended name for privatization which was meant to transfer assets and liabilities of NEPA to

PHCN. "It was officially commissioned on the fifth of May 2005 and was to carry out business of NEPA which were still on". In the same vein, the National Integrated Power Projects (NIPP) was inaugurated in 2004 to quicken the upgrading of capacity in the country. This was basically a private initiative which was supervised by the Niger Delta Power Holding Company (NDPHC) (Awosepe, 2014).

The PHCN was disaggregated into 18 independent firms as follows: six electricity generating firms, one electricity transmission firm, and eleven electricity distribution firms. The generating companies are Egbin Electricity Generating Company (EEGC), and those at Sapele, Ughelli, Afam, Shiroro and Kainji. There are also some new Independent Power Producers under the auspices of the Niger-Delta Power Holding Company (NDPHC). The "eleven distribution companies are the Electricity Distribution Companies of Abuja, Benin, Eko, Enugu, Ibadan, Ikeja, Jos, Kaduna, Kano, Port-Harcourt, and Yola respectively" (Awosepe, 2014). In 2010, the federal government rolled out the Road Map for the Power sector in Lagos with targeted achievements as shown in Table 1.

Table-1. The Road Map for enhanced power generation, transmission and distribution capability in Nigeria

Period	Available power generating capacity (MW)	Power Transmission capacity (MW)		Power Distribution capacity (MW)
		330.0 kv lines	132.0 kv lines	
2nd quarter 2010	4612.00	5155.00	6677.00	5768.00
Last quarter 2010	5379.00	5515.00	7328.00	6334.00
First quarter 2011	7033.00	5995.00	7328.00	6900.00
Last quarter 2011	9769.00	6555.00	7488.00	7485.00
Last quarter 2012	11879.00	7866.00	8986.00	8061.00
Last quarter 2013	14218.00	8653.00	9885.00	9059.00

Source: Olugbenga *et al.* (2013)

The Transmission Company of Nigeria (TCN) is 100 per cent owned by the government. 20 percent of the Generating companies (GENCOs) belong to the government and 80 per cent to private sector ownership. For distributing companies (DISCOs), 60 per cent is owned by private investors and 40 per cent by the government. From 30th September 2013, generation and distribution of electricity have been transferred to the private investors with the handing over to them of certificates of ownership by the government. On Wednesday February 12, 2014, the Nigerian Electricity Regulatory Commission (NERC) at a meeting with power generating and distributing companies in the country agreed to continue with the Transition Electricity Market (TEM). This means that electricity industry in the country presently operate under transition regime (Isola, 2012; Awosepe, 2014).

1.2. Structure of Electricity Market in Nigeria

In Nigeria, most electricity energy is generated through gas sources followed by hydropower, oil and then coal. Out of an installed generation capacity of 8,227 megawatts (MW), actual generation is only 3,716 MW giving a gap of 4511 MW. Transmission as well as distribution coverage is low compared to the vast land mass of Nigeria. Out of an estimated national electricity demand of 10,000 MW, generation deficit was 5,750 MW, indicating that more than about 57.5 percent of Nigerians are without public power supply. Table 2 gives available thermal installed plants in the country where aggregate installed capacity for the power generation plants is 5,976 MW but operational capacity is 2,589 MW, less than 50 percent of installed capacity. From Table 2, Sapele station was established over 26 years ago with total installed capacity of 1,020 MW but only 90 MW is currently available, the same story goes for Afam, Egbin and other old stations. This may be due to poor management of those stations.

Table-2. Thermal installed plants

Generating Station	State	Status	Age	Installed Capacity (MW)	Number of units installed	Current Number Available	Capacity Available (MW)	Operational Capability (MW)
Egbin	Lagos	Existing	23	1320	6	4	880	600
Egbin AES	Lagos	Existing	7	270	9	9	270	220
Delta	Delta	Existing	18	840	18	12	540	330
Sapele	Delta	Existing	26 - 30	1020	10	1	90	65
Omoku	Rivers	Existing	3	150	6	4	100	70
Ajaokuta	Kogi		N/A	110	2	2	100	80
Okpai		Existing	3	480	3	3	480	400
Geregu	Kogi	Existing	2	414	3	3	414	414
Omotosho	Ondo	Existing	1	335	8	2	80	75
Olorunshogo	Ogun	Existing	1	335	8	2	80	35
Afam	Rivers	Existing	26	702	20	3	350	300
Total				5976	93	44	3384	2589

Sources: Obadote (2009); Eberhard and Gratwick (2012); Olugbenga *et al.* (2013)

Table-3. Existing integrated power projects

Project name/site (technology)	State located	1st Phase installed capacity (MW)	2nd Phase installed capacity (MW)
Calabar	Cross River	563	-
Egbema	Imo	338	-
Ihovbar	Edo	451	-
Gbarain	Bayelsa	225	-
Sapele	Delta	451	-
Omoku	Rivers	225	-
			Continue

Alaoji	Abia	504	1000
Olorunshogo	Ogun	335	754
Omotosho	Ondo	335	754
Geregu	Kogi	414	414
Ibom power	AkwaIbom	193	450
Okpai		-	450
Eket (Mobil JV)	AkwaIbom	500	-
Obite (Totalfina Elf)		450	-
Ijede (Chevreon)		250	800
Mambilla (Hydro)	Taraba	2600	
		7837	4622

Sources: Obadote (2009); Eberhard and Gratwick (2012)

Table-4. Hydro power generating plants in Nigeria

Generating station	Location (state)	Age	Status	Installed capacity (MW)	units installed	Units available	Capacity available (MW)	Operational Capability (MW)
Kainji	Niger	38-40	Existing	760	8	6	440	400
Jebba	Niger	25	Existing	578	6	4	358.6	300
Shiroro	Niger	22	Existing	600	4	4	600	300
Mambilla	Taraba		Planned	2600				
Zungeru	Niger		Planned	950				
Total				5488	18	14	1431.6	1000

Source: Obadote (2009); Tallapragada PVSN (2009); Olugbenga *et al.* (2013)

Table-5. Profile of the electricity industry infrastructure in Nigeria

Generation:			**Pre-1999**	**Post-1999**
	- Thermal		4,058 MW	5,010 MW
	- Hydro		1,900 MW	1,900 MW
	Installed capacity		5,996 MW	6,910 MW
	Available Capacity		1,500 MW	4,451 MW
Transmission:		330.0 kv line	4,800.00 km	4,889.20 km
		132.0 kv lines	6,100.00 km	6,284.06 km
Transformer capacity:				
		330/132 kv	5,618.00 MVA	6,098.00 MVA
		132/33 kv	6,230.00 MVA	7,805.00 MVA
		33kv lines	37,173.00 km	48,409.62 km
		11kv lines	29,055.00 km	32,581.49 km
		415kv lines	70,799.00 km	126,032.79 km
			8,342.56 MVA	12,219 MVA

Source: Maigida (2008)

Table 3 shows the structure of the independent power plants (IPP) in the country. Installed capacity for all the IPP in the country is put at 12,459 MW but some of them are yet to fully function while some are yet to be completed. Table 4 gives a breakdown of hydro power plants in the country. From the table, out of installed capacity of 5,488 MW only 1,000 MW is available from all the plants, a short fall of about 82 percent. Table 5 gives a summary of electricity infrastructure before and after 1999, from here it is shown that after 1999, improvements were recorded on the megawatts of electricity generated, transmitted and distributed in the country, though the rate of improvements was not significant enough to fill the existing lacuna between electricity supply and demand in the country.

2. Empirical Literature

Empirical studies have been undertaken about issues concerning electricity supply and its impact on industrial or economic growth. However, this study concentrates its focus on the determinants of electricity supply in a developing economy as Nigeria. Focus on impacts of electricity supply is however borne out of the importance of electric energy as a vital source of economic or industrial growth of a country.

Jonah *et al.* (2013) investigated the impact of electric energy supply on the industrial sector productivity of Nigeria between 1970 and 2010. Data for the study were obtained from the reports and bulletins of Central Bank of Nigeria. The study adopted multiple regression analysis and modern econometric methodology. The results from the study showed that electricity supply in Nigeria does not significantly impact on industrial productivity of the country. However, the ADF tests results indicated that all the variables for the study were stationary at first difference and that there is a possibility of convergence of industrial output to equilibrium at the nearest future with equilibrium line points of -0.945. This result depicts the poor state of electricity supply in the country, because economic expectations are that electricity supply should contribute positively and significantly to industrial sector growth and hence economic growth.

In line with Jonah *et al.* (2013); Olayemi (2012) evaluated the impact of electricity crisis on manufacturing productivity growth in Nigeria. Time series data from 1980 to 2008 were analyzed using OLS multiple regression. The study's results showed that electricity generation and supply in Nigeria impacted negatively on manufacturing productivity growth. This was attributed to unnecessary government spending on non economic and unproductive sectors. They advised that electricity generation and distribution should be restructured through the initiative of independent power projects, i.e. there should be a reform of the power sector. This study did not however indicate whether the non economic and unproductive sectors include the power sector, because it took as one of its variables government capital expenditure on infrastructures.

Contrary views on the strength of contribution of electricity supply in Nigeria were given in Ubi and Effiom (2013). They studied the relationship between electricity supply and economic development in the country. Time series data for the study were analyzed using modern econometric technique. Stationarity and cointegration tests were carried out and estimation technique adopted was the error correction mechanism. The results indicated that despite the poor state of electricity supply in the country, it influences economic development, although its impact is relatively very low. Based on this, they recommend among others that more power projects should be completed, i.e. more power generation efforts should be made. This result corroborates Alawiye (2011) whose study showed that the power sector in Nigeria impacts positively on industrial development. Also, Nwankwo and Njogo (2013) used data from 1970 to 2010 and adopted the multiple regression model to show that electricity supply is positively related to real GDP per capita in Nigeria.

These and other conflicting studies on the relationship between electricity supply and growth of the economy may not give impetus for definite conclusion on the impact of electricity supply in the country's efforts to develop. In some instances however, the concept of electricity are misunderstood and conflicting data and variables are employed to determine electricity supply in Nigeria. More so, available studies on electricity supply determinants are few. Hence, there is need for more studies in this regard.

In recognition of this lacuna, Ubi *et al.* (2012) in an attempt to link electricity supply to economic development status of Nigeria, attributed the situation to the inability of policy makers to identify the determinants of electricity supply for effective policy formulation and implementation. In a bid to defining these determinants, their study, using parametric econometric methodology of OLS employed time series data from 1970 to 2009 to show that: technology, government funding, and the level of power loss were the statistically significant determinants of electricity supply in Nigeria. They recommended among others, the injection of more funds into the sector and more power plants to generate more electricity. This study made a giant stride in unfolding electricity supply determinants in the country, however, it failed to take into consideration reforms in the power sector and hence the impact of such reforms on electricity supply in the country and on the market structure of the electricity market which hitherto was monopolistic in nature. It is therefore needful that with the reforms in the power sector in Nigeria, structural changes due to such reforms should be captured as a variable that can determine electricity supply in the country.

In an attempt to capture the effect of electricity sector reforms, Isola (2012) undertook a purely descriptive study on the implication of electricity market structure on energy sector reforms and management in Nigeria. The focus of the study was on market structure, market design and supply gap in electricity generation within the context of power sector reforms. Considering the nature of the Nigerian political, social and economic climate, they concluded that electricity market reforms may be likened to fire, which if not regulated may produce more problems and if regulated will give better results. As noted earlier, the study was merely descriptive without strong analytical powers to determine the impact of the reforms processes on electricity supply in the country.

On the global scale, most studies available confirm the importance of electric energy to economic growth of any economy. As far back as the 1960s, Odell (1965) study for Colombia shows that electricity was very important for the growth and development of such a rapidly developing economy. Akinlo (2008) using the ARDL bound test showed that energy consumption has a significant positive long run impact on economic growth in Sub-Saharan African countries of Cameroun, Cote d'Ivoire, Gambia, Senegal, Sudan and Zimbabwe. Allcott *et al.* (2014) study adopted hybrid Leontief/Cobb-Douglas production function model and simulation calibrated to annual survey of industrial plants from 1992 to 2010 for India. Their analysis revealed that electricity supply shortage reduces average industrial output by five percent and raises energy costs by 0.24 percent of revenues, reduces productivity by 0.05 percent and reduces revenue by 0.78 percent. In the same vein, Scott *et al.* (2014) used data from the World Bank enterprise surveys from six countries: Bangladesh, Nepal, Nigeria, Pakistan, Tanzania, and Uganda to study the impact of electricity insecurity on small and medium scale firms. Their statistical analysis showed that electricity insecurity negatively affects total factor productivity and labor productivity of manufacturing small and medium scale enterprises' overall costs and it influences investment decisions and location. These further affirm the importance of electricity to economic process of any form of economy. Nepal and Jamasb (2011) studied the impact of power sector reforms on the economic, technical and environmental aspects of power sector, and the interactions between power sector reforms and economy wide sectoral level institutions since 1990. This was to examine the role of country level institutional structure and framework in explaining why some power markets (supply) work and some do not, based on the New Institutional Economics. The study was undertaken for a set of 27 diverse countries in Central Eastern Europe and Baltic States, South Eastern Europe, and Common Wealth of Independent States. A panel data econometrics based on bias corrected dynamic fixed effect analysis was performed to assess the impact of reform on macroeconomic and power sector outcomes. The results showed that power sector reform is greatly interdependent with reforms in other sectors in the economy. They concluded that the success of power sector reforms on power sector outcomes in developing countries will largely depend on the extent to which countries are able to synchronize inter sector reforms in the country.

3. Theoretical Framework

Isola (2012) submits that the performance of an organization, measured in terms of operational efficiency, is determined by its form of organizational structure. The two extremes of such structures are perfect competition and monopoly. While perfect competition is highly participatory with finite number of firms, free entry or exit, etc. monopoly is highly restrictive with one firm industry and restrictive entry. Also, perfect competition which is consumer friendly and protective encourages higher levels of economic activities and increases efficiency, while monopoly encourages inefficiency, limits economic activities and is consumer unfriendly.

In between the two extremes exists other market structures such as oligopoly, monopolistic competition, etc. However, it has been recognized that the electricity industry cannot fit into the more general perfect competition and monopoly models, because such models do not take into consideration the peculiar nature of such industry's market. As suggested by Isola (2012) oligopolistic competition models are the most suitable models for analyzing electricity market. The model is able to take cognizance of the technical characteristics, operational models and firms' behavior in the electricity market. Following Borenstein and Bushnell (1999), for electricity market, Cournot competition is preferred to Bertrand competition which according to Blake (2003) are the two major oligopolistic alternatives to consider. Preference for Cournot competition hinges on the fact that demand for electricity is high and electricity suppliers have limited capacity and increasing marginal costs and may not realistically fix prices below other competitors as suggested by Bertrand's assumptions (Hobbs, 1986).

The Nigerian electricity market has been under the monopoly of government agency from its early inception until about 2005 when major restructuring was made in the market through the Electric Power Sector Reform Act (EPSRA), the law was aimed at liberalizing the power sector. The long period existence of the market on monopolistic structure has no doubt affected electricity products in the country. Therefore this study, in line with Ubi *et al.* (2012) employed as its theoretical framework the elementary supply theory where supply in this context is not necessarily total stock of products produced, but that amount of the products actually supplied (i.e. offered for sale). Supply theory has it that the quantity of goods/services produced and supplied at a given time are determined by factors such as price of the commodity, cost of production, state of technology, natural phenomenon like weather condition, government policy, structural changes in the market, etc. The quantum and quality of electricity production and supply are also most likely determined by these factors. It is on the basis of these factors that we adopt the elementary supply theory as the framework for specifying the model for this study.

4. The Model and Data

This study covers the period from 1981 to 2015, which captures the period before and after major structural changes in the electricity market in Nigeria. Econometric approach for the study relies on time series data regression. The data for the study were sourced from Central Bank of Nigeria statistical bulletins and annual reports, Ministry of Power, National Electricity Regulation Commission, and World Bank climate change knowledge portal. The model specified follows those of Ubi *et al.* (2012) and Subair and Oke (2008). After testing for unit root and cointegration, the study estimated the error correction model by adopting the general to specific approach to determine the parsimonious estimate and eliminating jointly insignificant variables. The model for the study is:

$$ELS = f(PCGDP, ELP, TECH, ELCON, RAIN, GOVINV, REF) \qquad (1)$$

Where: ELS = Electricity Supply in Mega watt

PCGDP = Per capita gross domestic product measured in millions of Naira is a proxy for income;

ELP = Electricity Prices in Naira of Mega watt of electricity per hour (₦/MW/hr) is electricity tariff charged by the electricity distribution agencies in Nigeria;

TECH = Technology (time variance, a year is a data point)

ELCON = Electricity consumption in megawatt of electricity per hour

RAIN = Rainfall measured in millimeters (mm) of rainfall per year in Nigeria;

GOVINV = Government investment (expenditure) in the power sector (electricity) in millions of Naira

REF = Structural changes in the electricity market (0 and 1 for periods before (1981 to 2004) and after (2005 to 2015)) major market reforms in the power sector in Nigeria respectively.

For the regression function to be in an estimation form, Equation (1) is reformulated to include the stochastic error term:

$$ELS = b_0 + b_1PCGDP + b_2ELP + b_3TECH + b_4ELCON + b_5RAIN + b_6GOVINV + b_7REF + v \qquad (2)$$

Where: v = Stochastic Error Terms. Other variables are as defined earlier; b_1 to b_7 are the parameter estimates measuring the impact of the explanatory variables. Apriori expected parameter values are: $0 < b_1$ to b_7

5. Empirical Results

Table-6. Correlation Matrix for Electricity Supply Equation

	ELS	PCGDP	GOVINV	ELP	ELCON	RAIN	TECH	REF
ELS	1.0000	0.9587	0.6457	0.9296	0.9253	0.5362	0.8672	0.8330
PCGDP	0.9587	1.0000	0.9183	.8907	0.8498	0.4160	0.7830	0.8338
GOVINV	0.6457	0.9183	1.0000	.7872	0.7302	0.2958	0.6220	0.6655
ELP	0.9296	0.8907	0.7872	.0000	0.6533	0.7681	0.9357	0.7529
ELCON	0.9253	0.8498	0.7302	.6533	1.0000	0.5203	0.8385	0.8092
RAIN	0.5362	0.4160	0.2958	.7681	0.5203	1.0000	0.7992	0.3995
TECH	0.8672	0.7830	0.6220	.9357	0.8385	0.7992	1.0000	0.9573
REF	0.8330	0.8338	0.6655	.7529	0.8092	0.3995	0.9573	1.0000

Source: Computed by the Author (2016)

Table-7. The results of the augmented Dickey-Fuller (ADF) unit root tests

Variables	Level	1st Difference	2nd Difference	Remarks
GOVINV	0.493694	-4.603638***		I(1)
ELCON	-0.962527	-8.148139***		I(1)
ELP	1.181042	-5.412346***		I(1)
PCGDP	2.692490	-7.514412***		I(1)
RAIN	-1.551040	-5.836048***		I(1)
ELS	0.720391	-7.857469***		I(1)
REF	-0.594089	-5.744563***		I(1)

Source: Computed by the Author (2016)

Note: Test critical values (Constant): 1% level = -3.6422; 5% level = -2.9527; 10% = -2.6148

*** signify significance at 1%; ** signify significance at 5%; *signify significance at 10%

Table-8. Lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1197.727	NA	3.05e+26	75.17046	75.39948	75.24637
1	-1073.391	202.0466*	6.27e+23*	68.96193*	70.33606*	69.41742*
2	-1053.591	25.98750	9.82e+23	69.28693	71.80616	70.12199
3	-1024.473	29.11831	1.07e+24	69.02954	72.69388	70.24416

Source: Computed by the Author (2016)
* 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

Table-9. Cointegration tests results

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.993593	555.9773	219.4016	0.0000
At most 1 *	0.962501	389.3158	179.5098	0.0000
At most 2 *	0.950886	280.9624	143.6691	0.0000
At most 3 *	0.896882	181.5131	111.7805	0.0000
At most 4 *	0.766678	106.5410	83.93712	0.0005
At most 5	0.463444	58.51488	60.06141	0.0671
At most 6	0.407584	37.96962	40.17493	0.0819
At most 7	0.302867	20.69260	24.27596	0.1326
At most 8	0.233522	8.786889	12.32090	0.1819
At most 9	0.000320	0.010552	4.129906	0.9333

Source: Computed by the Author (2016)
Trace test indicates 5 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**probability-values

Table-10. Parsimonious ECM results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(ELP)	17.80081	6.939658	2.565084	0.0160
D(PCGDP(-1))	6.290377	1.333352	4.717716	0.0001
D(GOVINV(-1))	1.600000	0.413000	3.874092	0.0012
D(RAIN(-1))	2.924752	1.315747	2.222882	0.0345
DUM	1.569726	1.025153	1.521458	0.1407
ECM(-1)	-0.921981	0.477699	-1.930046	0.0638
C	70.40807	38.47160	1.830131	0.0779
R-squared	0.855014	Mean dependent var		110.8559
Adjusted R-squared	0.792695	S.D. dependent var		220.1628
S.E. of regression	197.8166	Akaike info criterion		12.17134
Sum squared resid	1095679.	Schwarz criterion		12.84070
Log likelihood	-224.7128	Hannan-Quinn criterion.		12.66320
F-statistic	2.575349	Durbin-Watson stat		1.905232
Prob(F-statistic)	0.048816			

Source: Computed by the Author (2016)

Pair-wise correlation analysis was undertaken to determine the level of relationship among the variables in the model. It was found that all the regressors in the model were found to have positive relationship with electricity supply. Some variables were found to highly correlate with others, for instance, the level of correlation between technology (TECH) and electricity price and also with reforms (REF) were about 94 percent and 95 percent respectively. Equally, electricity consumption (ELCON) was found to be highly correlated with electricity supply (ELS). To avoid the problem of multicollinearity and also gain degrees of freedom, TECH and ELCON were expunged as variables for estimation.

Both the augmented Dickey-Fuller and Philip-Peron tests were undertaken to determine the stationarity of the series regression for all the macroeconomic variables. Results of the tests using the augmented Dickey-Fuller technique indicated that all the variables in the equations were stationary at first difference at one percent significance and are therefore integrated of order one. The Johansen cointegration results indicated at most five cointegrating equations at five percent level of significance. This shows that there exist unique long run equilibrium relationships between the variables in the equation.

To assess the impact of power sector reforms on electricity supply in Nigeria, REF was regressed on aggregate electricity supply. Electricity price (ELP), per capita GDP (PCGDP), government investment in the power sector (GOVINV), and aggregate volume of rainfall (RAIN) were also added as major determinants of electricity supply. The parsimonious ECM result reveals that the error correction coefficient, which predicts the rate of speed with which the dynamic model restores back to equilibrium when it deviates and the speed with which variables would return to equilibrium was (-0.921 or 92.1 percent) negative and significant with t-statistics of -1.93 (approximately 2.0). As revealed, the speed of adjustment of 92.1 percent between the short-run and the long-run behaviors of electricity supply with its independent variables implies that adjustment is covered up within one year.

The level of efficiency and validity of an error correction model depends on the lag structures. The optimum lag length selection was undertaken using the following criteria: final prediction error (FPE); Akaike information criterion (AIC); Schwarze information criterion (SC); and Hannan-Quinn information criterion (HQ). The values of the four criteria all indicate that the chosen optimal lag length in Error Correction Model (ECM) for the model should be one (1). The value of adjusted R^2 which is 0.7926 means that about 79 percent of total changes in electricity supply is determined through variations in the independent variables. This shows a good fit for the equation. The F-statistics which measures the overall significance of the independent variables in the equation depicts that they are statistically significant at 2.58. Also, the Durbin-Watson statistics of 1.90 (approximately 2.0) indicate the absence of serial correlation in the equation, thus, the equation is good for policy analysis.

The results of the analysis further shows that reforms (REF) coefficient has positive sign (1.569) and was statistically insignificant with t-statistic of 1.52 and P-value of 0.14. This result indicates that structural changes in the power sector in Nigeria through the reforms of 2005 had positive coefficient but was statistically insignificant. This means that if the current market structure of the power sector in the country is improved and sustained, over time, it will help to boost electricity supply in Nigeria.

Electricity price (ELP), government investment in the power sector (GOVINV), annual rainfall (RAIN) and per capita GDP (PCGDP) all had positive coefficients and were statistically significant. The result here implies that increases in these variables will translate to increased electricity supply.

6. Discussion

The results affirm that structural changes in the power sector do not have significant impact on electricity supply in Nigeria though it possess positive coefficient. The structural changes here include the power sector market reforms which came into effect from 2005 with the commercialization, privatization and unbundling of the power sector. The positive coefficient may mean that if the reform is effectively sustained and synchronized with positive reformations in the different sectors of the economy, this could bring about positive impacts on electricity supply in the country. As shown by Nepal and Jamasb (2011) successful reformation of the power sectors in developing economies is largely dependent on the rate at which such economies will be able to effectively and simultaneously manage reforms in other sectors of their economies. As Isola (2012) noted, competition on its own does not guarantee success, rather, there should be a blend of competition with credible institutions.

Electricity price (ELP), government investment in the power sector (GOVINV), per capital GDP and annual rainfall (RAIN) were shown to impact electricity supply positively and significantly. These are in line with the apriori expectations of this study and economic prescriptions. This goes in tandem with Ubi *et al.* (2012) that these variables are among the major factors that determines the megawatts of electricity supplied in Nigeria, although their study showed that electricity price does not have reliable influence on electricity supply in Nigeria. The result here implies that increases in these variables will translate to electricity supply growth. The coefficient of rainfall reflect the nature of electricity generation sources in Nigeria, one of which is the hydro which constitutes about 36 percent of electricity generation sources in Nigeria after gas with 39.8 percent. The hydropower sources depend on the amount of rainfall. Also, since electricity production is highly capital intensive, proper funding of the sector as well as adequate pricing of electricity products are expected, as shown, to propel supply growth

7. Conclusion and Recommendations

Based on the results of this study, it is concluded that the present reform efforts in the power sector aimed at restructuring the electricity market from monopolistic to competitive structure will bring great improvements in the power sector of the country if properly harnessed and made to work simultaneously with similar reforms in other sectors of the economy.

Reforms in the power sector should be encouraged to work more efficiently with time, but there is need for the government to rather play the role of monitoring and regulating the market than being an active participant as is currently the case where it has 100 percent share in transmission, 40 percent share in distribution and 20 percent share in generation. It is therefore recommended that government should totally transfer ownership in all units of electricity production and supply chain to private investors.

Since the reforms in the power sector cannot effectively work in isolation or with inefficiently and ineffectively government managed sectors of the economy, for instance the petroleum sector, other sectors of the economy should also be reformed alongside to enhance simultaneous effective performance in all the sectors of the Nigerian economy

The study indicates that electricity price has positive impact on electricity supply. This means that with proper pricing of electricity services, supply can be enhanced. Though the current pricing system is geared towards achieving this, consumers should not be billed out of consumption, rather, as it is obtained in other electricity markets in the world, consumers in Nigeria should be made to pay only for what is actually consumed and not estimated consumption that is open to abuse by the electricity distribution agency officials. So, policy on electricity pricing should be made to be consumer, and as well market friendly. Also, proper measurement of electricity consumption should be made with internationally standardized meters.

From the results obtained from this study, it is shown that proper funding of the power sector will enhance electricity production positively. Since the sector is highly capital intensive, it needs adequate funding for it to be effective, policy should be directed at making adequate funds available to investors in the power sector. Financial institutions should be encouraged to provide funds at a lower cost to such investors. These funds will enhance the purchase and replacement of old and worn out transformers and other infrastructures that will help boost electricity supply in the country. However, when the funds are acquired, they should be appropriately channeled to meet the purpose for which they were acquired.

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