

Models for Forecasting the Demand and Supply of Electricity in Nigeria

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Abstract In this paper, the Garch model is used to determine the market volatility in the demand and supply chains of electricity in Nigeria for 36 years, i.e. from 1970 to 2005 from the historic data obtained from the National Bureau of Statistics. The Harvey logistic model is used to predict the demand and supply of electricity in the country from 2005 to 2026. From the results obtained, the demand and supply of electricity show mixture of spikes because of mean reverse behavior about the mean values and the demand outweighed the supply. The consequence of this is that there is vast market prosperity for investors in the power sector in Nigeria. It is estimated that about 317.5 billion US dollars business opportunities are available to new independent power stations in Nigeria.

Keywords: demand, supply, electricity, garch, Arima, Harvey logistic model

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1. Introduction

Electricity power supply is the most important commodity for the development of a nation. People become easily empowered to work and develop themselves when there is electricity power supply. This development takes place from domestic level to industrial level and can also be transferred from small to medium and to large scale level. Power consumption demand depends on the population and industrialization of a country [2,4,5,15]. There is power equilibrium when the supply is equal to the demand, otherwise there is supply shortfall.

Models for pricing, forecasting and supply of electricity are often characterized by spikes. Electricity is non-storable, hence the market is volatility and will change with time, and that is, the volatility has heteroscedasticity behavior which is a kind of time varying variance [13,14]. There are several researches done on modeling and forecasting the demand and supply of electricity. Oyelami [14] studied the dynamics of demand and supply of electricity pricing and Barlow's model was used to suggest that capping happen at some maximum price whenever demand exceeds the maximum supply.

Electricity supply in Nigeria dates back to 1886 when two small generating sets were installed to serve the then colony of Lagos. By an act of parliament in 1951, the Electricity Corporation of Nigeria (ECN) was established and in 1962, the Niger Dams Authority (NDA) was also established. However, a merger of the two was made in 1972 to form the National Electric Power Authority

(NEPA) as a result of unbundling and power reform process, it was renamed Power Holding Company of Nigeria (PHCN) in 2005 [15]. In February 2005, the World Bank agreed to provide PHCN with \$100 million to assist in its privatization efforts. In November 2013, the Federal government of Nigeria (FGN) concluded the privatization of power sector in Nigeria which led to selling of the PHCN to some privately owned companies.

Nigeria is a country blessed with a lot of resources such as coal, oil, natural gas, water and other renewable energy sources that can be used to generate electricity. The renewable energy being solar energy, biomass, wind, small and large hydropower with potential for hydrogen fuel, geothermal and ocean energies. Nigeria is Africa's major oil producing country which accounts for two-thirds of Africa's crude oil reserves. Talking about Nigerian natural gas reserves, it is estimated to be 187.44 trillion standard cubic feet in 2005 [16]. These reserves are known to be substantially larger than its oil reserves in terms of energy. Gas utilization for generation of electricity is said to be a primary goal for Nigeria. The first discovery of coal was in the year 1909; the mining began in 1916 with a recorded output of about 24,500 tons [5]. The poor industrialization and varying economic growth in Nigeria may be attributed to unreliable and inadequate power supply.

The socio-economic development activities in the country are responsible for the increase in demand for electricity. Mostly, this high demand can be found in the manufacturing and commercial sub-sectors. The problem of Nigeria appears to be lower electricity supply compared to the electricity consumption.

As at 2007, Nigeria has about 14 generating plants with an installed capacity of 7,876MW but the installed available capacity is less than 4000MW as at 2009. Nigerian electricity supply market has a lot of potential profit to investors if they invest in the generation, transmission and distribution of electricity. Generation of electric power in Nigeria is overwhelmed by excessive demand for electricity by consumers because of inadequate supply. This supply shortfall has resulted into unannounced load shedding, prolonged and intermittent power outages supplies to the consumers over the years. The total amount of electricity generated in Nigeria as at August 2013 dropped to 2,628.6 Megawatts [15].

Traditional financial models start with the Black-Scholes assumption of the Geometric Brownian Motion or log-normal prices. This assumption does not make sense in the context of electricity prices for many reasons including the non-predictability of electricity prices. A model which has been used in practice is known as the Ornstein-Uhlenbeck process. This is a continuous time model which permits autocorrelation. It is necessary to incorporate mean reversion when modeling electricity prices because of the electricity price jumps due to unexpected events.

Basically, there are three stages involved in the business of electricity; these stages are the generation, transmission and distribution of electricity. Power generation, transmission and distribution involve flow of currents with heat losses in conductors. These losses can be reduced through better design, construction and maintenance.

Objective of this paper is to compute the volatility of the electricity market by using the General Autoregressive Conditional Heteroscedasticity (GARCH) model and then predict the demand and supply of electricity in the country [7,8,12]. The Nigerian electricity market has been our focus. The data to be used is the yearly generation and consumption of electricity in Nigeria as obtained from the National Bureau of Statistics. The data spans from 1970 to 2005. From the available data on demand and supply of electricity there appear to be different kind of shortfall scenarios in the demand and supply chains in the country as far as electricity is concerned.

2. Methods

We shall use the GARCH models to study for changing volatility in demand and supply chain for period of 36 years, i.e. from 1970 to 2005. We will then make use of the Harvey logistic model to predict the demand and supply of electricity for country from 2015 to 2026.

2.1. Autoregressive Moving Average (ARMA) and Autoregressive Integrated Moving Average (ARIMA)

This class of stochastic process denoted by ARMA (p, q) is a combination of autoregressive process of order p and a moving average of order q parameterized as

$$r_t = \phi_1 r_{t-1} + \dots + \phi_p r_{t-p} + \varepsilon_t - \beta_1 \varepsilon_{t-1} - \dots - \beta_q \varepsilon_{t-q} \quad (1)$$

Or equivalently in a compact form we have $\phi(L)r_t = \beta(L)\varepsilon_t$

Where

$$\phi(L) = 1 - \phi_1 L - \phi_2 L^2 - \dots - \phi_p L^p$$

$$\beta(L) = 1 - \beta_1 L - \beta_2 L^2 + \dots + \beta_q L^q$$

If p and q are integers and $d \in (0,1)$ we say that the time series r_t is an ARIMA (p, d, q) series if $(1-d)^d r_t$ is stationary. ARMA (p, q) time series is defined by the infinite sum

$$(1-L)^d = 1 + \sum_{j=0}^{\infty} \frac{d(d-1)\dots(d-j+1)}{j!} (-1)^{d-j} L^j \quad (2)$$

Where the difference operator $(1-d)^d$

If after the d differencing, we can represent the above equation as

$$\phi(L)\nabla^d r_t = \beta(L)\varepsilon_t$$

$$\phi(L)(1-L)^d r_t = \beta(L)\varepsilon_t$$

Thus we have an ARIMA (p, d, q) model corresponding to an invertible ARMA (p, q) model after the d^{th} differencing. An examination of ARIMA (p, d, q) model shows that it varies generally with different combinations of p and q. We can possibly generate a wide range of time series models, if $d = 0$, the ARIMA model reduces to an ARMA model and when $p = d = q = 0$, it becomes a pure white noise.

2.2. Volatility

Statistically, we can say it is the measure of dispersion of returns for a given security or market index. Volatility can either be measured by using the standard deviation or variance between returns from the same security or market index. Commonly, the higher the volatility, the riskier the security. As regards option pricing, it is described as a variable expressing the extent to which the return of the underlying asset will fluctuate between now and the expiration date. In other words, volatility refers to the amount of uncertainty of risk about the size changes in the value of an asset. The mathematical representation of

volatility is given as $\sigma = \sqrt{\frac{1}{(n-1)} \sum (X - \bar{X})^2}$, σ

represents the volatility, n represents the number of observed elements, X represents each observed element and \bar{X} represents the mean of all observed elements.

2.3. Data and Descriptive Statistic

The data employed in this study contains the demand and supply of electricity commodity in Nigeria. The figures span from 1970 to 2005 amounting to 36 data points. The choice of this dataset was limited to the availability of data especially the absence of monthly figures for demand and supply of electricity which is expected to give us high frequency. All the annual data

series were obtained from the National Bureau of Statistics, Abuja, Nigeria.

Basically, it is a known fact that in nature, most economic series are non-stationary. We can therefore perform different types of transformation on the data series in order for us to make it stationary.

Let P_t denote value at time t and P_{t-1} the value at time t-1, and then the continuous compounded returns r_t are calculated from the corresponding first difference of the log of values expressed in percentage as

$$r_t = \ln\left[\frac{P_t}{P_{t-1}}\right]*100 \quad (3)$$

Our choice of the compounded returns above is due to the fact that we wish to linearize the trend which definitely leads to a stable variance. The compounded returns also exhibit additive property which is not shared by relative returns. This better illustrates this property; we wish to use the theorem given below:

THEOREM 1 [6]

If $X_t = \zeta_t \delta_t$, where $\delta_t = \left(\sum_{i=1}^p x_i(t).c_i\right)$

Then

$$\nabla \log x_t = \nabla \zeta_t + \nabla \delta_t$$

is a stationary process.

Proof

The only term we considered is $\nabla \eta_t$. Differencing the function

$$\log\left(\sum_{i=1}^p x_i(t).c_i\right) \text{ This leads to the results:}$$

$$\nabla \log\left(\sum_{i=1}^p x_i(t).c_i\right) = \sum_{i=1}^p \log(x_i(t).c_i)$$

$$\nabla \log x_i(t).c_i = \begin{cases} 0 & \text{if } t \neq a_i \\ c_i & \text{if } t = a_{i-1} \\ -c_i & \text{if } t = a_i \end{cases}$$

Hence we have a zero difference except at the partition point where the result is $\nabla \log \delta_t = c_i - c_{i-1}$ if $t = a_i$, $0 < i < p$. This completes the proof.

2.4. Tests for Stationarity

We wish to carry out checks on the respective return series which we obtained in order to find out if they are stationary or not. As stated above, this procedure is very much necessary due to the fact that no inference procedure can be applied to non-stationary series. Non-stationary series do not produce reliable estimates of parameters. We examined the graphs of both the demand-supply series and their return series with their respective Auto Correlation Form(ACF) and Partial Auto Correlation Form(PACF) to form a reasonable opinion on whether the series are stationary or not [6,14].

2.5. Estimation of the GARCH (1,1) Model

The descriptive statistics and other properties of return series such as mean, variance, mean, median, kurtosis, skewness, standard deviation etc. have serious implications for modeling. This is due to the fact that they provide good decision for the distribution and process that drives it.

We shall estimate the parameters α_0, α_1 , and α_2 of the GARCH (1,1) model using the Matlab. From the estimation we wish to obtain the market volatility. The GARCH model is given as

$$y_t = c + \varepsilon_t, \sigma_t^2 = \alpha_0 + \alpha_1 \sigma_{t-1}^2 + \alpha_2 \varepsilon_{t-1}^2$$

Where

y_t Represents the returns

ε_t Represents the error term (white noise)

σ_t^2 Represents the variance at time t

σ_{t-1}^2 Represents the variance at a previous time t-1

ε_{t-1}^2 Represents the error term at a previous time t-1

2.6. Derivation of the Electricity Demand and Supply Functions Using the Harvey Logistic Model

We are interested in developing a function for the demand of electricity commodity. Therefore we wish to use the Harvey Logistic Model [9,11] given below;

$$\ln y_t = 2 \ln y_{t-1} + \eta t + \varepsilon_t \quad (4)$$

Where Y_t is the electricity consumption in year t and $y_t = Y_t - Y_{t-1}$ for $t=2 \dots T$.

ε_t is a disturbance term with zero mean and constant variance.

We shall therefore use ordinary least square method of regression to calibration the model.

Therefore, $\ln y_t = 2 \ln y_{t-1} + \eta t + \varepsilon_t$. Now let $\ln y_t = w_t$ and $u_t = \ln y_{t-1}$

Hence,

$$w_t = 2u_t + \eta t + \varepsilon_t \quad (5)$$

$$\begin{aligned} \sum_{t=1}^n w_t &= 2 \sum_{t=1}^n u_t + \eta \sum_{t=1}^n t + \varepsilon_t n \\ &= 2 \sum_{t=1}^n u_t + \eta \frac{n}{2} (n+1) + \varepsilon_t n \end{aligned} \quad (6)$$

If we multiply equation (5) by u_t , then we have

$$u_t w_t = 2u_t^2 + \eta \frac{n}{2} (n+1) u_t + \varepsilon_t u_t \quad (7)$$

$$\sum_{t=1}^n u_t w_t = 2 \sum_{t=1}^n u_t^2 + \eta \frac{n}{2} (n+1) \sum_{t=1}^n u_t + \varepsilon_t \sum_{t=1}^n u_t \quad (8)$$

We will use the ordinary least square method of regression [3] to obtain the disturbance or error term ε_t and η .

The supply function formula can be obtaining from the equation below:

$$\sum_{t=1}^n p_t = 2 \sum_{t=1}^n u_t + \eta \frac{n}{2} (n+1) + \varepsilon_t n$$

$$\sum_{t=1}^n p_t q_t = 2 \sum_{t=1}^n q_t^2 + \eta \frac{n}{2} (n+1) t \sum_{t=1}^n q_t + \varepsilon_t \sum_{t=1}^n q_t$$

The data analyzed in this study consist of both the demand and supply available data for electricity for the Nigerian electricity market. Each data is represented by a series of 36 data points, so there are two different series with a total of 72 data points. Their time plots are presented in Figure 1. All computations and analysis are done using the matrix laboratory (MATLAB) software package and the statistical package for social sciences (SPSS).

3. Results

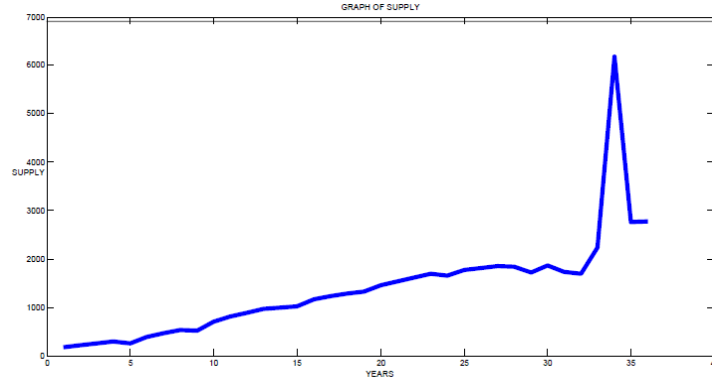


Figure 1. Time plot of the yearly supply of electricity. Source: Nigerian Bureau of Statistics

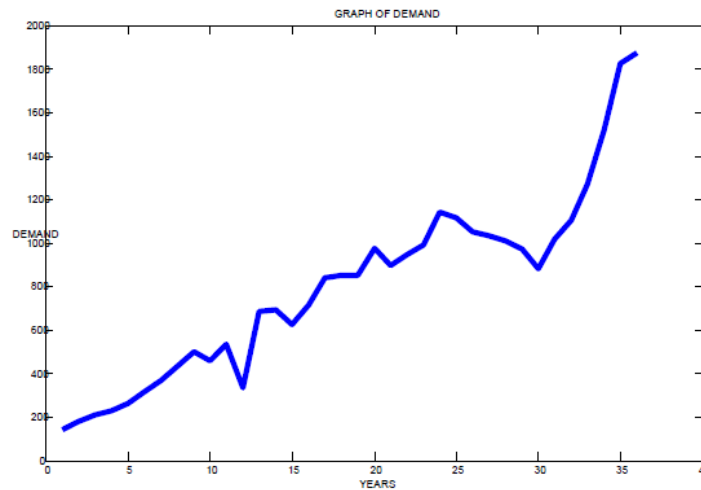


Figure 2. Time plot of the yearly demand of electricity, Source: Nigerian Bureau of Statistics

3.1. Continuous Compounded Returns

We transformed the supply and demand series into returns series in order to eliminate the effects of the

random variations detected in the plots of the supply and demand data series. The results obtained by the use of equation (1) are presented below:

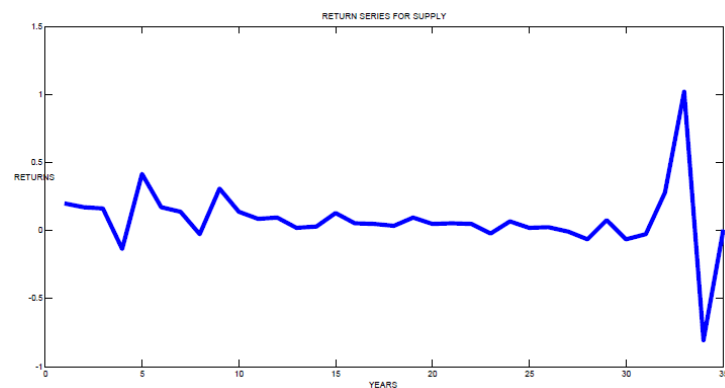


Figure 3. Time plot of supply returns

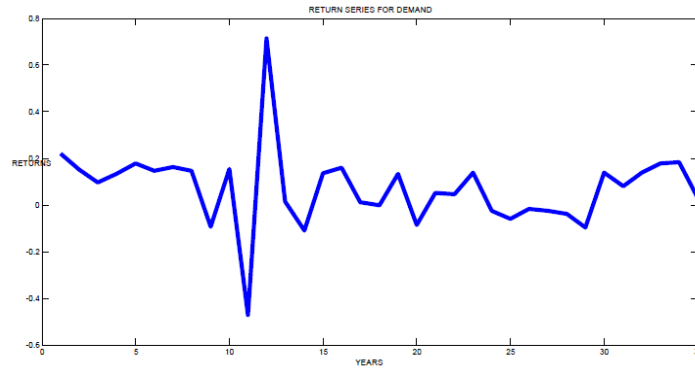


Figure 4. Time plot of demand returns

In the demand and supply return time plots in Figure 1 and Figure 2 there is stationarity in the return series. The demand shows mean reversal property. It goes up and returns to the mean and goes down and returns to the

mean. There are also spikes in the demand and supply because of data size which is small because of the information in the Table 1 and Table 2 were on annual basis which led to smaller spikes.

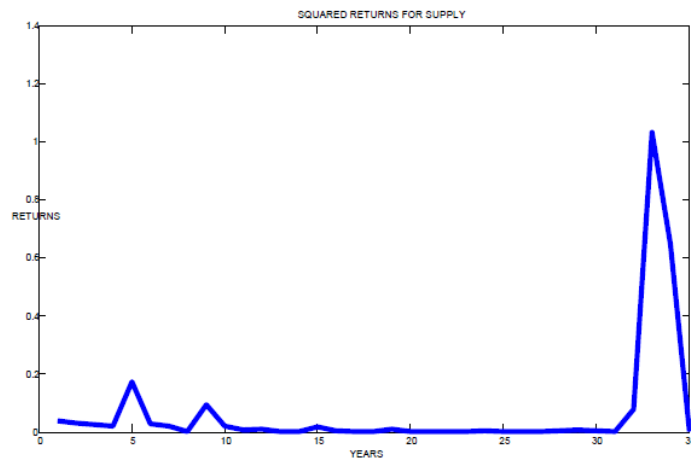


Figure 5. Time plot of supply squared returns

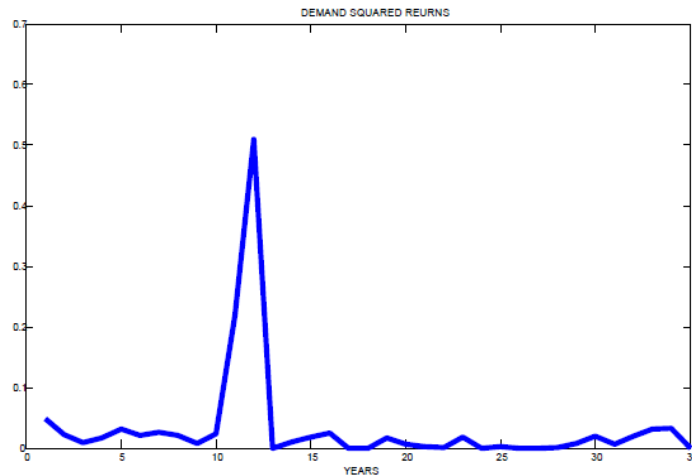


Figure 6. Time plot of demand squared returns

The noticeable feature of the two time series of returns suggests that fluctuations occurred at different amplitudes though very low amplitudes. There are periods of very short turbulence and longer period of relative calmness. This is due to the fact that our data series is very small. However, square return allows perfect stationarity. The Figure 5 is the time plot of supply squared returns and Figure 6 is the time plot of demand squared returns to allow the data to be stationary.

Table 2 provides the general overview and preliminary statistics of the respective returns for both data series

obtained for the period under preview. These include the mean, minimum, maximum, standard deviation skewness and kurtosis. The large difference between the maximum and minimum is due to the fact that there are some levels of fluctuations in the returns. The mean and standard deviation of the two data series are significant. Both series are leptokurtic in nature although there is no indication of negative skewness due to the size of the data.

Using the SPSS software we obtained the following results:

Table 1. Descriptive statistics for the return series

	SAMPLE SIZE	MEAN	MIN	MAX	STD DEV	SKEW	KURT
SUPPLY	36	0.0809	-0.8048	1.0160	0.2499	0.333	9.763
DEMAND	36	0.7310	-0.4690	0.7135	0.1725	0.542	7.015

Skew is a measure of heavy tails and asymmetry of a distribution (normal) and kurtosis is measure of too many observations around the mean for a distribution (normal).

The Matlab code for estimating the garch parameters is:

```
>> whos
>> y=price2ret (demand);
>> [coeff, errors, LLF, innovations, sigma, summary]
=garchfit (y);
>> garchdisp (coeff, errors);
```

From the garch parameter code we obtained the results in the Table 2 and the Table 3 as follows:

Table 2. Parameter estimation of GARCH (1,1) for the supply data series

PARAMETER	VALUE	T-ERROR	STATISTICS
C	0.054263	0.0075726	7.1657
a ₀	0.0029131	0.0025178	1.11570
GARCH(1)	0	0.17768	0.0000
ARCH(1)	1	0.13258	7.5427

Table 3. Parameter estimation of GARCH (1,1) for the Demand data series

PARAMETER	VALUE	T-ERROR	STATISTICS
C	0.029746	0.0023232	1.2804
a ₀	0.0057212	0.010356	0.5525
GARCH(1)	0.022733	0.46612	0.0488
ARCH(1)	0.97727	0.77949	1.2537

From Table 1, we can therefore set up the GARCH (1,1) model with the appropriate estimated values:

$$y_t = 0.054263 + \varepsilon_t$$

$$\sigma_t^2 = 0.0057212 + \varepsilon_t^2$$

From Table 3, we can therefore set up the GARCH (1, 1) model with the appropriate estimated values as follows:

$$y_t = 0.029746 + \varepsilon_t$$

$$\sigma_t^2 = 0.0057212 + 0.022733\sigma_{t-1}^2 + 0.97727\varepsilon_{t-1}^2$$

From the above equation, we used the Monte Carlo simulation to obtain the white noise ε_t from the demand data series, from which we now obtained the variance to be 0.0066.

Hence our volatility = $\sqrt{0.0066} = 0.0812 * 100 = 8.12\%$.

3.2. Statistical Computation on Demand and Supply Variables

Table 4. Statistical computation on Electricity supply

supply	$z_t = z_t - z_{t-1}$	$\ln z_t$	$z_t = p_t$	$z_{t-1} = p_t$	$p_t q_t$	q_t^2
176.6	176.6	5.1739	5.1739			
215.4	38.8	3.6584		3.6584	18.7215	13.3839
255.4	40.0	3.6889	3.6889			
299.7	44.3	3.7910		3.7910	13.9846	14.3717
261.1	-38.6	3.6533	3.6533			
395.4	134.3	4.8978		4.8978	17.8931	23.9884
468.7	73.3	4.2946	4.2946			
538.0	69.3	4.2384		4.2384	18.2022	17.9640
522.7	15.3	2.7279	2.7279			
710.7	188	5.2364		5.2364	14.2844	27.4199
815.1	104.4	4.6482	4.6482			
887.7	72.6	4.2850		4.2850	19.9175	18.3612
973.9	86.2	4.4567	4.4567			
994.6	20.7	3.0301		3.0301	13.5042	9.1815
1025.5	30.9	3.4308	3.4308			
1166.8	141.3	4.9509		4.9509	16.9855	24.5114
1228.9	62.1	4.1287	4.1287			
1286.0	57.1	4.0448		4.0448	16.6998	16.3604
1330.4	44.4	3.7932	3.7932			
1462.7	132.3	4.8801		4.8801	18.5112	23.8154
1536.9	74.2	4.3068	4.3068			
1617.2	80.3	4.3858		4.3858	18.8888	19.2352
1693.4	76.2	4.3334	4.3334			
1655.8	-37.6	3.6270		3.6270	15.7172	13.1551
1772.9	117.1	4.7630	4.7630			
1810.1	37.2	3.6163		3.6163	17.2244	13.0776
1854.2	44.1	3.7865	3.7865			
1839.8	-14.4	2.6672		2.6672	10.0991	7.1140
1724.9	-114.9	4.7441	4.7441			
1859.8	134.9	4.9045		4.9045	23.2674	24.0541
1738.3	-121.5	4.7999	4.7999			
1689.9	-48.4	3.8795		3.8795	18.6212	15.0501
2237.3	547.4	6.3052	6.3052			
6180.0	3942.7	8.2796		8.2796	52.2045	68.5518
2763.6	-3416.4	8.1363	8.1363			
2779.3	15.7	2.7537		2.7537	22.4050	7.5829
			81.1714	77.1265	347.1315	357.1786

Table 5. Statistical table for Electricity Demand

consumption	$y_t=Y_t-Y_{t-1}$	$\ln y_t$	$y_t=w_t$	$y_{t-1}=u_t$	$w_t u_t$	u_t^2
145.3	145.3	4.9788	4.9788			
181.1	35.8	3.5779		3.5779	17.8136	12.8014
211.1	30.0	3.4012	3.4012			
232.7	21.6	3.0727		3.0727	10.4509	9.4415
266.2	33.5	3.5115	3.5115			
318.7	52.5	3.9608		3.9608	13.3121	15.6879
369.8	51.1	3.9338	3.9338			
435.7	65.9	4.1881		4.1881	16.4751	17.5402
504.4	68.7	4.2297	4.2297			
460.1	-44.3	3.7910		3.7910	16.0348	14.3717
536.9	76.8	4.3412	4.3412			
335.9	-210	5.3033		5.3033	23.0227	28.1250
685.6	349.7	5.8571	5.8571			
696.7	11.1	2.4069		2.4069	14.0975	5.7932
625.5	-71.2	4.2655	4.2655			
717.4	91.9	4.5267		4.5267	19.2830	20.4367
841.8	124.4	4.8235	4.8235			
852.9	11.1	2.4069		2.4069	11.6097	5.7932
853.5	0.6	-0.5108	-0.5108			
976.8	123.3	4.8146		4.8146	-2.4593	23.1804
898.5	-78.3	4.33605	4.33605			
946.6	48.1	3.8733		3.8733	16.8895	15.0025
993.0	46.4	3.8373	3.8373			
1141.4	148.4	4.9999		4.9999	19.1861	24.9990
1115.0	-26.4	3.2734	3.2734			
1050.9	-64.1	4.1604		4.1604	13.6187	17.3089
1033.3	-17.6	2.8679	2.8679			
1009.6	-23.7	3.1655		3.1655	9.0783	10.0204
972.8	-36.8	3.6055	3.6055			
883.7	-89.1	4.4898		4.4898	16.1880	20.1583
1017.3	133.6	4.8949	4.8949			
1104.7	87.4	4.4705		4.4705	21.8827	19.9854
1271.6	166.9	5.1174	5.1174			
1519.5	247.9	5.5130		5.5130	28.2122	30.3932
1825.8	306.3	5.7246	5.7246			
1873.1	47.3	3.8565		3.8565	22.0770	14.8726

We obtained the following from the supply data series

$$\sum p_t = 81.1714, \sum q_t = 77.1265$$

$$\sum p_t q_t = 347.1316, \sum q_t^2 = 357.1786$$

We obtained the equations below

$$-73.0816 = +666\eta + 36\varepsilon$$

$$-367.2256 = 51366.249\eta + 77.1265\varepsilon$$

In matrix form we have,

$$\begin{pmatrix} 51366.249 & 77.1265 \\ 666 & 36 \end{pmatrix} \begin{pmatrix} \eta \\ \varepsilon \end{pmatrix} = \begin{pmatrix} -367.2256 \\ -73.0816 \end{pmatrix}$$

$$\eta = -0.0042$$

$$\varepsilon = -1.9520$$

The values of η and ε for the demand and supply variables and plotting of graphs are obtained using the following Mat lab code in the appendix. Hence, the supply function is given as

$$\ln z_t = 2 \ln z_{t-1} - 0.0042t - 1.9520$$

We, therefore, obtained the following from the demand series.

$$\sum w_t = 72.5130, \sum u_t = 72.5718$$

$$\sum w_t u_t = 286.7726, \sum u_t^2 = 305.9115$$

We have two equations

$$72.513 = 145.1436 + 666\eta + 36\varepsilon$$

$$286.7726 = 611.823 + 48332.8188\eta + 72.5718\varepsilon$$

Hence, in matrix form we have

$$\begin{pmatrix} 666 & 36 \\ 48332.8188 & 72.5718 \end{pmatrix} \begin{pmatrix} \eta \\ \varepsilon \end{pmatrix} = \begin{pmatrix} -72.6306 \\ -325.0504 \end{pmatrix}$$

$$\therefore \eta = -0.0038 \text{ and } \varepsilon = -1.9472$$

The demand model is then given as

$$\ln y_t = 2 \ln y_{t-1} - 0.0038t - 1.9472$$

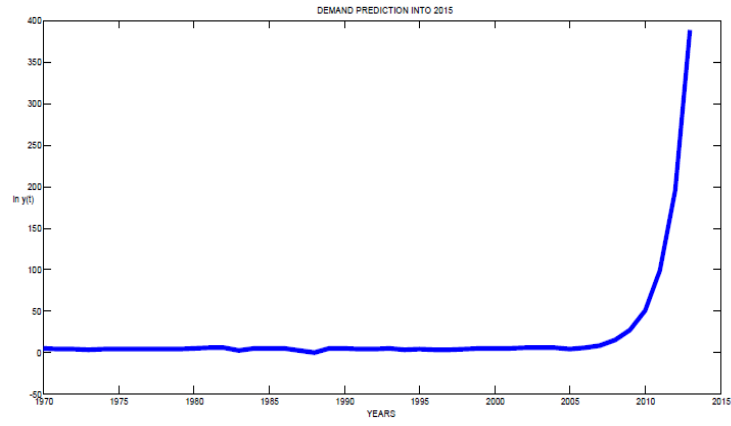


Figure 7. Graph of demand prediction

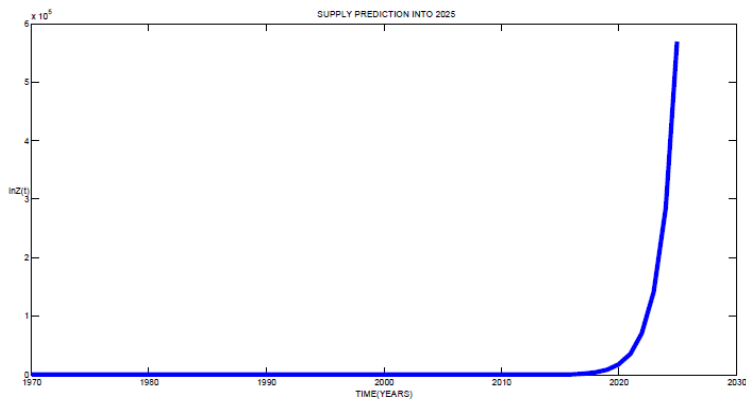


Figure 8. Graph of supply prediction

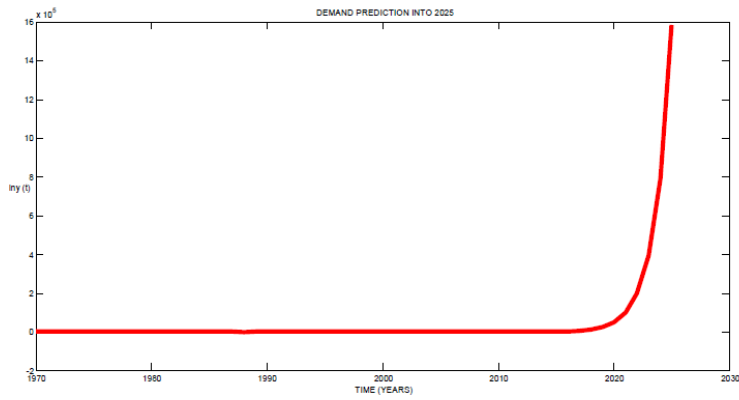


Figure 9. Demand of electricity prediction

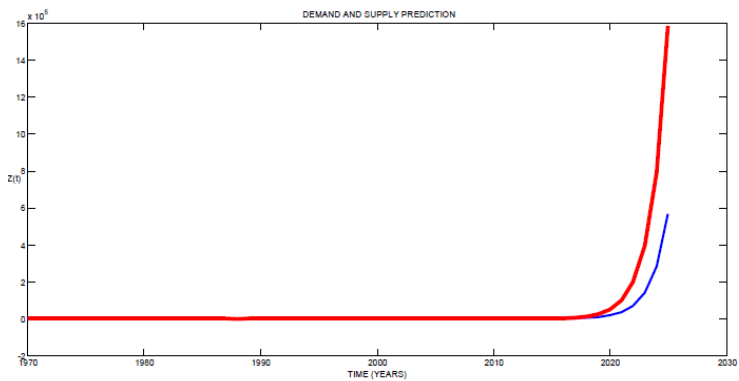


Figure 10. Graph of electricity demand and supply from 1970 to 2026

The prediction for electricity demand and supply is obtained from the Harvey model by extrapolating the data from the year 2005 to 2026. The prediction value clearly indicates that the demand for electricity in Nigeria is continuously increasing and clearly outweighed the supply from Figure 10. Therefore, there are investment potentials for investors in the area of generation, transmission and distribution of electricity.

4. Conclusion

The National Electricity Regulation of Nigeria had suggested the minimum electricity requirement of Nigeria is about 50,000 Megawatts. At the moment the nation can boast of 4000 Megawatts, that is, a power shortfall of about 46,000 Megawatts. 1 kilowatt of electricity in Nigeria costs 13 naira and 165 naira is equivalent 1 US dollar. Therefore, the profit to be made if the shortfalls are supplied by new independent power stations, by simple calculation, is 317.48 billion US dollars. Therefore is vast window of opportunities open to investors in power section in Nigeria.

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Appendix

Matlab code for supply function parameters

```
>> Syms ('x', 'y')
>>% INPUT THE VALUE of companion matrix
>> A= [51366.2490 77.1265; 666 36]
A =1.0e+04 *5.1366 0.0077 0.0666 0.0036
>> % input the value of vector b
>> b= [-367.2256;-73.0816]
b = -367.2256-73.0816
>> % compute the inverse of matrix A
>> Inv (A)
Ans =0.0000 -0.0000-0.0004 0.0286
>> x=inv (A)*b
x =-0.0042-1.9520
```

Matlab code for demand function parameters

```
>> Syms ('x', 'y')
>>% Input the value of the companion matrix A2
>> A2= [666 36; 48332.8188 72.5718]
A2 =1.0e+04 *0.0666 0.0036 4.8333 0.0073
>>% input the value of vector b2
>> b2= [-72.6306;-325.0504]
b2 =-72.6306-325.0504
>>% compute the inverse of A2
>> Inv (A2)
Ans =-0.0000 0.0000 0.0286 -0.0004
>> x=inv (A2)*b2
x =-0.0038-1.9472
>> t=1970:1:2013;
>>% import values of ln y and ln z .
>> plot (t, lnz)
>> plot (t, ln y)
>> plot (t, lnz, t, ln y)
```