Interfuel Substitution and Allocative Efficiency in Electricity Production in Nigeria

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Abstract

The reason of this paper is to examine the inter fuel substitution likelihood and allocative efficiency between the two major fossil fuel inputs (oil and gas) used in the production of electricity in Nigeria. The problem is studied generally within a CES functional form representation, which was later reduced to a C-D functional relation. We estimated a weakly separable production function for oil and gas fuelled electric energy production independent of other factor inputs. The estimation procedure adopted ADRL approach using time series data for the period 1970-2006. The results obtained from the analysis indicate that the elasticity of substitution between the inputs is one, and therefore, producers could easily take advantage of price changes to ensure allocative efficiency in their inputs combination for oil and gas. However, the analysis in respect of allocative efficiency showed that the production process was inefficient in allocation of inputs. The conclusion provides future directions for inter fuel substitution in the thermal electricity production in Nigeria.

Keywords: Substitution, elasticity, eectricity production, CES, Nigeria.

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1. Introduction

The self-evident importance of the power sector in contemporary societies and economies constitute a first reason for deep academic interest in the field, particularly the need for an appropriate energy mix in the generation of electricity. The potential for inter fuel substitution in electricity production is clearly very large since electricity can be produced by any of the fossil fuels i.e oil, gas and coal, as well as by hydro and nuclear power. Our focus is on two of the fossil fuels (oil and gas). What combination of fuels producers choose depends on the relative costs of the alternatives. Nevertheless, for policies intended at controlling fuel options to become capable for an understanding of the components. Our study focuses on the flexibility in the Nigerian fuel-usage in energy sector. To this end, this paper sets out to examine the nature and magnitude of substitution, distribution and efficiency parameters of CES production function model of electricity production in Nigeria. In addition, we intend to determine the elasticity of substitution between oil and gas, as fuel inputs for the sector and test for the allocative efficiency in the use of these inputs. It is expected that the result from this investigation will provide further empirical evidence for necessary policy options in respect of the appropriate fossil fuel mix in electricity generation in Nigeria. Besides, it will also illuminate the substitutability among the fossil fuel used in the Nigerian power sector.

The rest of this paper is structured as follows: section 2 is centered on the overview of electricity generation in Nigeria. In section 3, a review of literature is carried out on inter fuel substitution. The analytical framework and methodology are the focus of exposition in section 4 while section 5 is on the empirical results and discussion. Lastly, section 6 concludes the paper.

2. An Overview of Electricity Generation in Nigeria

2.1 Early Private Power Generation Companies

From the time electricity was introduced in Nigeria, and the time the federal government embarked on reforms, three main periods are discernible. The first is the period that predated the establishment of the Electricity

Corporation of Nigeria (ECN) in 1951. That was a period of isolated generation facilities with low rates of electrification. Electricity supply at this time in Nigeria was confined to a few urban areas and to mining centers. The first generation plant was installed at Ijora, Lagos, in 1898. This was undertaken by the then colonial government under the jurisdiction of the Public Works Department (PWD); it was to cater for both official and domestic needs of the colonial government. Later, other electricity undertakings were set up by the Native and Municipal Authorities in different parts of Nigeria.

In 1925, a privately owned company, the Nigerian Electricity Supply Company (NESCO), commenced the generation of electricity using a 2MW hydro-electric dam at Kurra falls, near Jos. The plant was set up primarily to supply tin mines with electricity. The plant was not only able to do this, but it also supplied steady electricity to Jos and its environs. Similarly, the African Timber and Plywood Limited started to operate its plants at Sapele in 1930; while the Shell Development Company of Nigeria equally operated at Bonny and Delta areas in 1942.

2.2 The Electricity Corporation of Nigeria

By 1950, the need for coordination and integration of the operating plants was considered necessary. This was the second phase in the development of electricity generation in Nigeria. In response to that necessity, the colonial government established the Electricity Corporation of Nigeria (ECN) through Ordinance No. 15 of 1950. This ordinance brought under one umbrella all the electricity undertakings owned and controlled by the Native and Municipal Authorities under the Public Works Department. The powers and functions of the ECN were set out in sections 21, 29, 30 and 50 of the 1950 Ordinance.

At the completion of the Niger Dam Hydro- electricity project at Kanji in 1962, the Niger Dam Authority (NDA) was established; a parallel electricity body came into existence. The NDA was mandated to oversee the development of hydro electric facilities in Nigeria. The enabling Act charged NDA with the responsibility for constructing and maintaining dams and other projects on the River Niger and elsewhere in Nigeria. Its functions also included generating electricity by means of water power, improving navigation and promoting fisheries and irrigation.

Based on the then prevalent buck passing between ECN and NDA on intermittent power failure in Nigeria, the third was reached when, the federal government decided to merge the two organisations into one single body. Decree No. 24 of 1972 gave the necessary legal backing. The decree mandated NEPA to maintain an efficient, coordinated and economical system of electricity supply for all parts of the federation. NEPA thus became a government monopoly, responsible for the production, transmission and distribution of electricity to final consumers. The supply of electricity in Nigeria became wholly dependent upon the capability of NEPA, its generation capacity, transmission and distribution facilities. NEPA's generating capacity as of December 31, 1999 was 6,010MW. In 2005, at the time of initiating the power sector reform, the following electricity generating plants existed.

Table 1 Installed Capacity of Generation Power Stations**.**

Power Station	Installed Capacity (MW)	Year of Establishment
Ijora Thermal	-	1956
Afam Thermal	972	1962
Delta Thermal	820	1966
Kainji Hydro	760	1968
Jebba Hydro	578	1985
Lagos Thermal	1320	1986
Shiroro Hydro	600	1989

Source: Power Holding Company of Nigeria (PHCN) Headquarters, Abuja

The only coal – fired power station at Oji in Enugu State, was commissioned in 1956. Because this four (4) steam plant had become obsolete and aging, it was recommended for scrapping. The isolated stations at Calabar, Kaduna, Makurdi, Mubi, Maiduguri, Minna and Suleja are operated off – line to serve specified cities.

In line with the global trend of Independent Power Producers (IPPs), NEPA's generation section made a number of Power Purchase Agreements (PPA). The first of such was the 270MW power purchase agreement with ENRON/AES at Egbin in Lagos State. It came on stream in September 2001. Another of such agreements was the Abuja captive power purchase agreements with the Geometric Power Inc. and Aggreko International Projects Ltd for 15MW electricity each from a set of diesel engine generators.

With government plans to privatize NEPA there have been a lot of new investments in the generation segment of the industry by the federal, state governments and corporate organizations. On the 1st of April 2005, President Obasanjo then commissioned the NNPC/AGIP power station at Okpai in Delta State. The new gas-powered generating station was expected to add 330MW to the national grid. NEPA was also expected to add latest by 2007, 2000MW of electricity from five (5) new power stations which are located at Papalanto in Ogun State; Omotosho in Ondo State; Geregu in Kogi State, Delta III in Delta State and Alaoji in Abia State (FGN, 2005).

In addition, the National Economic Council approved the construction of seven (7) new power stations in the Niger Delta area of the country. The seven power stations are expected to add a modest 2500MW to the national grid and would be located in Eyean in the outskirts of Benin; Ahovbar village in Edo State; Egbema area of Imo State; Gbarain/Ubio area of Bayelsa State; Ikot-Abasi in Akwa-Ibom State; Omuku in Rivers State and Calabar in Cross – River State.

Among other new initiatives by state governments, it has also been reported that the Imo State Government has signed an agreement with a consortium of gas plant manufacturers led by a United States company ANOOLO/SAR JVLCC, Anolokarju; Icc to build a 540MW gas powered generating station at Oguta for the total sum of $300 million (N41.1 billion). The project is expected to be completed within 21 months between 2006 and 2007.

3. Literature Review

Inter fuel substitution has received scholarly attention in electricity literature. In this section, an attempt is made to discuss few studies related to electricity production. Moxnes (1986) analysed the inter fuel substitution in OECD-European electricity production. One purpose of the paper was to investigate how much of the different fuels (oil, gas and coal) are chosen for different underlying costs. Another purpose of Moxnes's (1986) paper was exploring the adjustment period, that is, whether long or short time. For both purposes, a simulation model of inter fuel substitution was developed using a priori data about the costs among different power plants; life-time of equipment and the extent of short-term flexibility in electricity production. The model indicated that in the long run all fuels can be substituted for each other. In addition, this study showed that a considerable difference in average cost of the different options is needed to rule out an inter fuel substitution completely. The model also indicated that the adjustment process is dominated by the long life – term of plants. Probably less than 30 percent of production is flexible in the short run.

Similarly, Soderhom (1999) analyzes short-run inter fuel substitution between fossil fuels in West European power generation. The limited translog equations revealed some reasonable outcomes about the economics of *ex post* fossil fuel alternative. The results were quite consistent with the belief that short-run fuel substitution largely occurred (a) by switching load between different single-fuel fired plants; (b) in multi-fuel fired plants, and; (c) by the alteration of electrical units to be able to burn up alternative available fuels. Significant evidence of inter fuel substitution was found, specifically between gas and oil fuel combinations.

The implication of the result is obvious, as short-term fuel switching enabled power generators to exploit price differentials in fuel prices. The consequence is that fuel suppliers faced a ceiling on their fuel prices charged and the prospect for exploiting any market power was limited. Since the existence of multi-fuel plants limits price increases for everyone in the electric power system, generators who have no short-run flexibility whatsoever also benefit. In addition, it is likely that the trend away from long-term contracts between fuel suppliers and utilities towards annual negotiations (and spot purchases) is partly a result of the increased flexibility in the power sector. Consequently, the production and investment decisions of many fuel suppliers will have to be based more on current and future market conditions rather than on 'fixed' negotiated prices.

In Nigeria, there are few studies conducted on inter fuel substitution. Perhaps, the most recent study is the Adeyemo, Mabugu and Hassan (2007) paper. The intention of our study was to examine energy substitution option the industrial sector Nigeria is using various fuel types. For nine large industries; a model (inclusive of a translog cost function) was estimated. It consist of basic metal, non-metal, fabricated metal, food and beverages, chemicals, paper, wood, textile and others. Fuels were categorized into four types, i.e., electricity, oil, gas and coal. Estimations were performed using data over the period of 1970 - 2000. The results varied across the industries for different fuels. Specifically, the result established that oil and gas, and oil and coal are more of substitutes than complements in most industries. This implied that increasing the price of oil will increase the demand for gas and coal in most of the industries. Thus, it was evident that an increase in the price of oil would increase the demand of other fuels like gas, electricity and coal. This study is a departure from the work of Adeyemo et al, as its focus of attention of is on the inter fuel substitution possibility and allocative efficiency between the two major fossil fuel inputs used in the production of electricity from thermal sources in Nigeria. The methodology of research is discussed in the next section.

4. Analytical Framework and Methodology

Produced energy (E) in general functional form is E = E(K, L, N) where K is capital input, L is labour, and N is a natural resource input converted into energy. In most studies on interfuel substitution, this production function is assumed weakly separable in the inputs such that N input(s) as a group are weakly separable from K and L inputs. Thus the mix of N inputs (in this study oil and gas) is independent of non-energy inputs(K and L). This assumption of weak seperability not only allow us to analyse separate production function for energy input(s) alone, but also help reduce the number of parameters to be estimated (see Matsukawa et al ,1993; Soderholm, 1999; Considine, 1989 and Thompson, 2006). Under these assumptions, the production function for fossil fuelled electricity production of the general form is specified as such:

$$Q = f(X_1, X_2) \tag{1}$$

For estimation purposes we are interested in a functional form that enables us to track substitution between inputs. The translog production function proposed by Christensen et al (1971,1973) and used in many studies (see Griffin et al, 1976; Matsukawa et al,1993; Soderholm, 1999; and Thompson, 2006; Adeyemo, 2007) will come as a frontline candidate. Other relevant functional forms that could help address questions regarding elasticity of substitution among inputs include the Constant Elasticity of Substitution (CES) function and the popular Cobb-Douglas(C-D) function. Despite the obvious advantages of the translog specification, it was not adopted in this study because of its intensive data requirements, which we could not meet in this present study. The C-D function implies a unitary elasticity of substitution among the arguments of the function. In addition the C-D represents a special case of the CES function. Some of these difficulties can be avoided if a CES function is adopted. Apart from allowing elasticity of substitution to be a value other than one, its formula is additive and it can be used even when some data points are zero or negative.

Given the foregoing, we adopted the use of the CES functional form and represent our fossil fuel produced electricity production relationship thus:

$$Q = A\left[dX_1^{-P} + (1-D)X_2^{-P}\right]^{-v/p-e} \tag{2}$$

Where:

Q= output of electricity produced using oil and gas as fuel

X_1= oil as fuel input

X_2= gas as fuel input

With the following constraints:

- The distribution parameter (*d*): 1>*d* >0
- The efficiency parameter (*A*): *A>0*
- The return to scale parameter *(v);V>0*
- The substitution parameter (*p*) cannot be zero for a CES function, *p* $\geq$ 0

Through further derivations the model is reduced to an unrestricted linear specification of the form:

$$LnQ = B_o + B_1 LnX_1 + B_2 LnX_2 + B_3(LnX_1 - LnX_2)^2 \tag{3}$$

Which is now estimated using an OLS technique. We can observe that equation (3) is made of two parts. The first part corresponds to a C-D function. The second part represents a 'correction' due to the departure of *P* from zero. Thus if the estimate of B_3 is not significantly different from zero, the CES model is rejected in favour of the C-D model (Rahji and Omonoma , 2001).

Consequently, the following conditions hold:

A= antilog of B_0

$D= B_1$

$V = B_1 + B_2$

$$p = \frac{-2B_3(B_1 + B_2)}{B_1 B_2}$$

The test for allocative efficiency will consist of a null hypothesis of the form:
H_o: $X_1 = a_1 X_2 + U$

Against some other specified restrictions, which include:

$H_1 = a_1 + a_2X_2 + U$
$H_2 = a_2X_2 + a_3X_2^2 + U$
$H_3 = a_1 + a_2X_2 + a_3X_2^2 + U$
$H_4 = a_2X_2 + a_3X_2^2 + a_3X_2^3 + U$
$H_5 = a_1 + a_2X_2 + a_3X_2^2 + a_4X_2^3 + U$

The decision criterion is based on comparing the estimated R^2 values for the alternative hypotheses with that of the null hypothesis. The decision rule is that if R^2 for null hypothesis equation is greater than the alternative hypotheses, then allocative efficiency is accepted. If it is lower than that of the alternative hypotheses then the hypothesis of the presence of allocative efficiency in the production relation is not sustained. This is predicated on the intuition that for homogenous production functions the expansion path will be a straight line which passes through the origin. The slope (which determine the optimal input ratio) of the line will depend on the ratio of factor prices (Koutsoyiannis,1979; Rahji and Omonoma,2001).

4.1 Nature and Source of Data

The data needed to estimate the model included fossil fueled electricity production (Q), quantity of fossil fuel (in this particular case petroleum oil and gas) used to produce the electricity (X_1, X_2). The data for Q, X_1, and X_2 were sourced from the World Development Indicators (2008) and the Central Bank of Nigeria Statistical Bulletin (various issues). That of X_1 and X_2 were not directly available but computed from the information on oil electricity produced using these fuel sources. There is a good deal known about the Physics of converting various natural resources to energy (see Soderholm, 1999 and Thompson, 2006). Based on this we used standard International Energy Agency (IEA) and the USA Energy Information Administration (EIA) conversion units to obtain the series for $X1$ and X_2. Thus the Q was measured in Mwh while X_1 is measured in barrel of oil equivalent (Boe) and X_2 in thousand British thermal unit (MBtu). The analysis covers the period 1970 to 2006.

4.2 Estimation Issues

The method of analysis is basically time series econometric. A multiple regression analysis was employed in analyzing the data via OLS. Owing to the nature of the data we begin by examining the time series property of the data using mainly Augmented Dicky-Fuller unit root test followed by some diagnostic tests to assure us of policy relevance of the result of the analysis. Among these were the Autoregressive Distributed Lag (ARDL) Bounds testing for co-integrating relationship among variables (for details on this approach and its advantages over other approaches in testing for co-integrating relationship see Omisakin, 2009; Fosu, et al., 2006). Furthermore the test statistic used for the Bounds testing in this study is based on the extension of Pesaran, et al (2001) for smaller samples (30 to 80 data points) by Narayan (2004). We also explored the error correction specification to capture the dynamics of adjustment mechanism from short to long run equilibrium.

5. Empirical Results and Discussion

In Table 2 we present the results of ADF unit root tests on the variables. This shows that two of the variables are stationary at levels while the other two are stationary after differencing them once. This suggests that coefficients obtained from level regression of the variable will be useless both for analysis and/or policy purposes. We

Table 2 Unit Root Test Result

VARIABLE	ADF Statistics (at levels)	ADF Statistics (at 1st Difference)	Order of Integration
lnQ	-2. 608986	-6.348316•	I(1)
Ln X_1	-3.604595••		I(0)
Ln X_2	-2.463538	-5.564019•	I(1)
(Ln X_1- Ln X_2)^2	-5.555404••		I(0)
Critical value@1%	-4.252879	-4.252879	
Critical value@5%	-3.548490	-3.548490	
Critical value@10%	-3.207094	-3.207094	

• Significant at 10% ,•• Significant at 5% ,••• significant at 1%
Source: Authors' Computation

recalled that Engle and Granger (1987) showed that the establishment of co-integration among the variables could correct for this anomaly. However because of the different order of integration of the variables the Johansen multivariate procedure becomes infeasible. The (ARDL) bounds testing approach to co-integration is applicable in the presence of I(0) or I(1) variables. But the assumption of bounds testing will collapse in the presence of I(2) variable (Fosu et al., 2006). The result, therefore, implies that the bounds testing approach is applicable in this study since none of the variables is stationary at more than first difference.

The result of the (ADRL) bounds testing co-integration test is presented in Table 3. Essentially, it shows that the variables are co-integrated. Specifically, the computed F-statistic value of 6.250 is higher than the critical

Table 3 Bounds Testing for Cointegration Analysis

Computed F-statistic: 6.250 (lag structure, k = 1)
Critical bound's value at 5% Lower: 3.160 and Upper: 4.358
Critical bound's value at 1% Lower 4.522 and Upper: : 6.128
(Three regressors and no trends in the model)
Narayan, (2004) Appendix A1 Case II:

Note: The lag length k=1was selected based on the Schwarz criterion (SC).
Source: Authors' Computation

value of the upper bound at 1% and 5% critical values respectively. Therefore, we can conclude that a long-run relationship exists between the variables of the model and we can assuredly proceed to obtaining long-run coefficients for the model.

Table 4 Long-Run Coefficient From ARDL Estimation for Q

Dependent variable	lnQ
Constant	7.424***
	(287.05)
Ln X_1	0.833***
	(69.95)
Ln X_2	0.1722***
	(16.426)
$(\text{Ln } X_1 - \text{Ln } X_2)^2$	0.0997***
	(52.193)
R-Squared	0.99
Adj.R-Squared	0.99
D.W. statistics	1.203
F-Statistics	210261.0
AIC	-6.7050

* Significant at 10% , ** Significant at 5%, *** Significant at 1%
Figures in parenthesis ( ) are t-ratios.
Source: Authors' Computation

Having established the long run relationship among the variables, the long run equation is estimated using the ARDL specification. The results are reported in Tables 4 and 5. At this juncture we are set to answer the questions about inter fuel substitution, which is the main focus of this research. In table 4, the result of the estimated equation confirms the assumption of CES but a closer scrutiny of the model shows the violation of some important statistical and econometric requirements, particularly autocorrelation. Consequent upon this, using a general–to-specific modelling approach guided by AIC, we selected a model that is most reliable for our analysis. This is presented in Table 5. Comparatively, its statistical property is better than the one in Table 4, though the variables were entered at their stationary level.

Table 5 Parsimonious Differenced Equation From ARDL Estimation for Q

Dependent variable	D(lnQ)
Constant	-1.665•••
	(-5.244)
Ln X_1	0.123•••
	(5.135)
D(Ln X_2)	1.13•••
	(20.800)
(Ln X_1- Ln X_2)^2	-0.0057
	(-1.248)
R-Squared	0.94
Adj.R-Squared	0.93
D.W. statistics	2.24
F-Statistics	165.830
AIC	-1.8176

•Significant at 10%, ••significant at 5%, ••• significant at 1%
Figures in parenthesis ( ) are t-ratios.
Source: Authors' Computation

An important result observable from the parsimonious differenced equation is that the assumption of CES functional form is not sustained. This is because the coefficient of the third variable is not statistically different from zero even at 10% level of significance. The main importance of this is that the relation becomes a C-D functional form. Given this, it means the elasticity of substitution between the variables is one. It shows also that in the production of electricity (using oil and gas) as inputs there is considerable room to substitute one fuel input for the other within the period of our analysis. Furthermore, this indicates that, as one fuel becomes relatively cheaper producers should use it more to ensure allocative efficiency in their production process. This result is not significantly different from that obtained by Matsukawa et al, (1993) and Soderholm, (1999), where it was established that substantial inter fuel substitution is present in existing power plants in Japan and Western Europe respectively, especially between oil and gas. This is similar with the idea that short-run fuel substitution mainly happens in multi-fuel fired units, by alternatively changing loads across

Table 6 Parsimonious Error Correction Representation for Q Equation

Dependent variable	D(lnQ)
Constant	-1.801***
	(-5.677)
Ln X_1	0.134***
	(5.574)
D(Ln X_2)	1.138***
	(21.553)
(Ln X_1- Ln X_2)^2	-0.0075
	(-1.643)
ECM(-1)	3.68*
	(1.73)
R-Squared	0.94
Adj.R-Squared	0.93
D.W. statistics	2.24
F-Statistics	165.830
AIC	-1.8176

* Significant at 10%, ** significant at 5%, *** significant at 1%
Figures in parenthesis ( ) are t-ratios.
Source: Authors' Computation

single-fuel fired units. However, if the result of our error correction representation model presented in Table 6 will tell us anything, it will be that the adjustment process may not be so smooth as the error correction term, which shows the pattern of the adjustment process, is not only wrongly signed, but it is also not statistically different from zero.

On the issue of allocative efficiency, we present the result of our analysis in Table 7. As articulated earlier, the main concern here is to compare the R-Square of the model of the null hypothesis to that of the alternative hypotheses. The result showed that the R-Square of the null is 0.41, while the R-Square of the entire alternative hypothesis is within a range of 0.74 to 0.76. The value of the R-Square of the null hypothesis means that gas input cannot explain more than 42% of the variation in the use of oil input. Therefore equation of the null hypothesis which gives a straight line that

Table 7 Results of Estimated Hypothesis Equations

Hypothesis	H_0	H_1	H_2	H_3	H_4	H_5
Dependent Variable	X_1	X_1	X_1	X_1	X_1	X_1
Constant		5.39		-12.58		14.48
		(6.45)		(-1.23)		(0.12)
X_2	0.827	0.499	1.212	2.85	0.362	-2.49
	(138.05)	(9.74)	(21.14)	(2.14)	(0.531)	(-0.108)
X_2^2			-0.023	-0.076	0.087	0.274
			(-6.722)	(-1.76)	(0.33)	(0.182)
X_2^3					-0.0036	-0.0076
					(-1.25)	(-0.233)
R-Squared	0.42	0.74	0.754	0.76	0.76	0.76
Adj.R-Squared	0.42	0.73	0.746	0.75	0.75	0.74

Figures in parenthesis ( ) are t-ratios.

Source: Authors' Computation

passes through the origin provides a poor fit of the data. The equations of the alternative hypotheses give better fit of the data. In fact, H_2 and H_4 which are quadratic and cubic functions respectively (with R-Square of 0.75 and 0.76) and having no intercept fit the data best. With these equations it is quite clear that the association between oil input series and gas input series in the thermal electricity production in Nigeria cannot be represented by a straight line passing through the origin. Thus all the alternatives are higher and therefore for this study, the allocative efficiency claim in input use (oil and gas) in fossil fuel electricity production in Nigeria within the period covered by this study is found to be empirically invalid.

6. Conclusion

This study has explored the inter-fuel substitution relation among oil and gas as fossil fuel inputs in thermal electricity production in Nigeria within the period 1970-2006. Following a generally CES functional form representation that was later reduced to a C-D functional relation we estimated a weakly separable production function for oil and gas fuelled electric energy production independent of other factor inputs. The estimation procedure adopted generally followed the (ADRL) approach. The result obtained from the analysis indicated that the elasticity of substitution between the inputs is one and therefore producers could easily take advantage of price changes to ensure allocative efficiency in their inputs combination for oil and gas. But the experience in Nigeria within the period covered by the analysis showed that the operators of the thermal generating units for electricity production had not utilized this advantage.

This result appears similar to the conclusion of earlier study conducted by Baron (1992). According to Bacon the picture from O.E.C.D countries was that within the homogeneous power generation sector not only was fuel substitution possible, but that it actually took place and that in some countries there were an extraordinary shift in the fuel mix used, which were largely influenced by natural resource endowment. In other words, the choice of fossil fuel to use in the generation of electricity goes beyond the cost structure to include availability of resources and deliberate government policy. Perhaps, this has explained the situation in Nigeria where there are proliferations of gas power plants in recent times. According to Isola (2007) the federal government promised to complete 22 gas fired plants by 2010 to improve the nation's electricity generating capacity; thus reflecting the inclination of the government towards gas fired plants. Besides, the implementation of the Gas Master Plan has added another impetus for the growth of the gas fired plants in Nigeria. However, to the extent that some of these gas plants remained idle for a long period because of shortage of gas supply, this appears to sustain our conclusion that the allocative efficiency of input used (oil and gas) for electricity production in Nigeria was found to be empirically invalid. Therefore, government should address the problem of Niger Delta crisis with its attendant negative impact on gas supply.

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