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EMPIRICAL RELATIONSHIP AMONG TECHNICAL EFFICIENCY, MACROECONOMIC VARIABLES AND INDUSTRIAL POLICY REGIMES: A case study of Sugar Industry in Nigeria

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ABSTRACT

The study estimated and analyzes technical efficiency indices in the sugar industry in Nigeria in the period 1970 to 2010. Secondary data were obtained from the sugar firms, Food and Agricultural Organization, Central Bank of Nigeria, National Bureau of Statistics and Federal Ministry of Finance. Unit root tests were conducted on the specified data to ascertain their stationarity and order of integration. Stochastic Cobb-Douglas production function for the sugar industry was estimated from which indices of technical efficiency were obtained by using frontier 4.1 software. Trend in the technical efficiency indices showed relatively unstable and fairly downward fluctuations with an average index of 50.80% and excess technical efficiency rate of 49.20%. Multiple-regression of various forms based on the ordinary least squares technique was used to determine the factors that influence technical efficiency in the industry. Empirical result revealed that technical efficiency in the sugar industry was influenced by the industry's sales growth, capital-labour ratio, official tariff rate on sugar import, real exchange rate and the liberalization policy period. To increase the technical efficiency of resource use in the sugar industry, restrictive policy measure on sugar imports through periodic review of tariff rate and quantity restriction on sugar import is strongly advocated. Also, capital intensive method of production should be adopted as a means of promoting efficiency of resource use in the industry. Furthermore, effective marketing policy on the industry manufactures is strongly recommended. Finally, the industrial policy package for the industry during import substitution period should be promoted in the sugar sub-sector in Nigeria.

Keywords: *Technical efficiency, macroeconomic variables, policy, sugar, production, Nigeria*

1. INTRODUCTION

In Nigeria, sugar sub-sector is one of the contributors to economic development (NSDC, 2010). The importance of the sub-sector is derived from its contribution to the employment generation and food self sufficiency as well as creating a significant impact on the rural economy in the country (Nwaobi, 2005; ADB, 2000 and ADF, 2000). The demand for direct household sugar consumption remains firm in the country and the soft drink production alone accounts for about half of total industrial sugar usage in the country (Michael, 2010). According to reports by the Central Bank of Nigeria (2008) and National Sugar Development Council (NSDC) (2010), the current domestic consumption of sugar in Nigeria is in excess of one million tonnes per annum. Currently, the domestic production of sugar is slightly less than 5% of the country's annual requirement (CBN 2008, and NSDC 2010). From 2001 to 2003, the domestic sugar production declined significantly reaching all time low value of less than 1.00% of domestic sugar consumption in the country (NSDC 2010 and Table 1).

Table 1: Sugar Supply and Import Price of Sugar in Nigeria (1970-2008)

Year	Average domestic output (tons)	Average import (tons)	Average total supply (tons)	Average Import Price ₦/ton	Share of domestic output in total (%)	Share of import in total (%)
1970-1972	38141	114158	152299	144.4	33.41	66.59
1973-1975	42594	99335	141929	424.6	30.01	69.99
1976-1978	34074	327382	361458	332.6	9.43	90.57
1979-1981	36296	632379	668675	349.8	5.43	94.57
1982-1984	37778	571562	609340	293.7	6.20	93.80
1985-1987	51872	450130	502002	465.2	10.33	89.67
1988-1990	51080	292766	343846	1878.5	14.86	85.14
1991-1993	40735	485540	526275	6681.5	7.74	92.26
1994-1996	45577	390718	436295	7696.6	10.45	89.55
1997-2000	13654	729870	743524	10980	1.84	98.16
2001-2003	5597	903066	908663	25229	0.62	99.38
2004-2008	11194	350113	361307	42625	3.20	96.80

Sources: FAO database (2011) and NSDC for various years.

In the early 1990s, the Nigerian sugar sub-sector was still largely underdeveloped with untapped resources and potentialities. The existing sugar companies were completely government owned and was characterized by low productivity occasioned by managerial, financial and infrastructural constraints. With the dwindling fortune of the federal government resources, the existing sugar companies were wallowed in low productivity due to inadequate finance for both recurrent and capital expenditure (NSDC, 2003).

Over the years, the government has employed several policy measures to increase the manufacturing capacity in the economy and at the same time curb excessive fluctuation of some key macroeconomic variables. The government policy measures varied from the pre-structural Adjustment Programme (Pre-SAP) period (1970-1985) to the SAP (1986-1993) and post-SAP (1994 to date) periods. Direct monetary control techniques were employed in the pre-SAP period (Anyanwu *et al,* 1997). In the SAP period (1986-1993), indirect monetary measures were used to control the ability of banks to extend new credit alongside credit ceilings. The measures included the deregulation of interest rates, increase in commercial banks cash reserve requirements and its extension beyond demand deposit to include time and savings deposits among others. In the post-SAP period (1994 to date), administratively controlled measures were first adopted in 1994 and were abandoned in 1995 for policy of guided deregulation. Apart from monetary policies, the government also employed some fiscal policy measures to ensure full employment and efficiency of resources in the manufacturing sector. The measures include tax holidays, tariff protection, import duty relief, bans on imports and the provision of credit facilities.

In the sugar industry, some specific policies had been employed over the years to boost sugar production in the country. These policies include; 50% tariff on the importation of white sugar, 5% levy on imported raw sugar, free excise duties on sugar production, reduce import duties on sugar industry machineries, 5–year tax holidays to sugar refineries and privatization of the major sugar firms in the country, as well as the sugar expansion programme in collaboration with the African Development Bank (ADB) and African Development Fund (ADF) in 1989 and 1991 respectively. These measures were meant to stimulate local production and hence increase the productivity in the sub-sector. Also the National Sugar Development Council (NSDC) was established by decree 88 of 1993. The NSDC was mandated to develop strategies that would promote local production of sugar such that 70% of the country's sugar requirement would be met by domestic production (Busari *et al.,* 1996 and NSDC, 2003). Based on the government policy of direct participation and investment in the sugar industry, NSDC strategies were the expansion and rehabilitation of the four government owned sugar industries, establishment of 5 medium scale and many mini sugar plants in the country as well as the establishment of sugarcane Research Development and Training Center. The Council however recorded some successes in implementing some of its strategies but could not still upsurge local production of sugar in the country (NSDC, 2003). In spite of these measures, Nigeria still imports over 90% of its sugar mostly in semi-processed form (NSDC, 2011). The country has the largest demand for sugar in the West Africa sub-region and second in Africa in addition to large area of cultivable land suitable for the growing of industrial sugarcane (Busari *et al.,* 1996, ADB and ADF, 2000). Despite the favorable agro-climatic and edaphic conditions for the production of sugar-cane in addition to the long period of existence of sugar mills; sugar requirements of the country remains largely unmet from domestic sources (Olomola, 2007). The cost implication of sugar imports in the country is devastating: for instance, about ₦26billion or about $173.33million (at ₦150 for 1 dollar) was spent on sugar importation in 2008 (Nigerian Business Financial News, 2010); while ₦217 billion or ($1.45b) was spent in 2010 (CBN, 2011).

Therefore based on issues raised and the need to assess the level of resource utilization as well as efficiency in the industry, this study has provided answers to the following questions: how technically efficient is sugar production in Nigeria? What factors influenced technical efficiency in the sugar industry from 1970 to 2010 in Nigeria? Which industrial policy regime(s) promoted high performance of sugar industry in Nigeria? Given the importance of the sugar industry in the Nigeria's economy, there is an overwhelming need to identify the fundamental variables that are responsible for the surging performance of the industry over the years. The study specifically establishes the empirical relationship among technical efficiency in the industry, some key macroeconomic factors and industrial policy regimes in the country.

2.0 LITERATURE REVIEW

Tybout *et al.,* (1990) used correlation analysis to investigate the relationship between technical efficiency of firms and the rate of effective protection in Chile in the period 1967 to 1999. The result revealed negative significant correlation between the variables. Alam and Morrison (2000) employed regression analysis to firm's related data from Peru manufacturing sector between 1988 and 1992 to obtain similar result. They also discovered that firm's size had a negative significant effect on the technical efficiency of firms. Njikam (2000) in Cameroon, found a positive significant relationship between manufacturing firm's technical efficiency and effective protection, official tariff rates, import penetration ratio, and share of manufacturing in exports. Chirwa (2000) also confirmed positive significant relationship between firm's technical efficiency and share of manufacturing in exports, capital-labour ratio and worker skill in Malawi. The result also showed that tariff rate, share of manufacturing in imports and firm size had negative significant relationship with firm's technical efficiency. Albert *et al.,* (2002) analyzed factors explaining technical efficiency in Spanish industrial sector in the period 1991 to 1994. The result revealed that technical efficiency had a significant positive relationship with the firm size and investment level and a negative relationship with expenditure in research and development. Djankov and Murrell (2002) in their empirical investigation concluded that privatization improves firm performance and efficiency and in addition that concentrated ownership enhances firm performance. Admassie (2002) explores technical efficiency level of small and medium scale enterprises (SMEs) in Tanzania, and found that the mean technical efficiency level for all firms is about 50 percent, meaning that by operating at the full technical efficiency levels, these firms could increase their productive level by about 50 percent. The study also indicates that the technical inefficiencies of the Tanzanian SMEs are significantly related to firm age, firm size, and human capital development.

Alvarez and Gustavo (2003) conducted a study on the determinants of technical efficiency in small firms in Chilean manufacturing industry. Using plant survey data and Non - Parametric Deterministic Frontier Methodology, they estimated efficiency that was positively related to the experience of workers, modern capitals, and innovation in products. In contrast, outward orientation, owner's education and participation in public programs have significant negative impact on firm's efficiency. Ray (2003) investigated the impact of economic reforms on the manufacturing efficiency in India in the period 1991 to 2001. The finding supported positive relationship between firm's efficiency and import liberalization in India.

Tien (2004) applied Data Envelopment Analysis (DEA) Approach to measure relative operating efficiency of eight major Taiwan steel making firms in terms of sale revenues. He discovered an average technical efficiency of about 87.3%. Badunenko and Andreas (2004) used cross sectional data from 241 industries in Germany between 1995 and 2001 to estimate technical efficiency and its determinants. The results revealed that technical efficiency was positively and significantly influenced by the index of new firm formation and human capital, and negatively correlated to the concentration indices. The results also showed that technical efficiency was not related to sales growth, research and training expenditures, capital intensity and firm size. A similar study was conducted by Badunenko *et al.,* (2006) using panel data from 35,000 German firms in the period 1992 to 2004. The report indicated that the firm size increases the technical efficiency while outsourcing, research and development decrease technical efficiency. Faruq and David (2010) used the Data Envelopment Analysis (DEA) technique to estimate the technical efficiency of firms in Ghana across six manufacturing industries during 1991 to 2002 period. They observed that the manufacturing firms in Ghana were significantly less efficient than their counterparts in other countries. In addition, their results reveal that firm characteristics such as size, age, foreign ownership, and the mix of labor and capital used during the production process have positive effects on firm's efficiency. Hung *et al.,* (2009) employed a Stochastic Frontier Approach on data drawn from the Vietnam enterprise survey for 2005 to estimate technical efficiency in the manufacturing sector. The result reveals an average technical efficiency of 63%. Niringiye *et al,* (2010) also investigated the relationship between technical efficiency and firm size in Uganda and Tanzania manufacturing sector. The result showed a negative association between firm's size and technical efficiency in both countries. Chu and Kaliappa (2010) examined the impact of trade liberalization and other variables on Vietnamese manufacturing firm's efficiency. The results revealed that trade liberalization and share of skilled workers have significant positive effect on the sector's efficiency, while capital-labour ratio had a negative influence. In Nigeria, Ogun (1987) and Soludo and Adenikinju (1996) conducted empirical researches on the performance of manufacturing sector in various policy regimes in the country. The results revealed positive relationships between technical efficiency in the manufacturing sector and import substitution period in the country. Also Adewuyi (2006) study the impact of trade policy reform on technical efficiency in Nigeria's manufacturing sector. The result revealed that the nominal protection rate and import penetration ratio had positive significant effects on the technical efficiency of the manufacturing sector. Negative effects were obtained for the interest rate and exchange rate respectively. The study concluded by asserting that the trade policy reform produced positive impact on the technical efficiency in the Nigeria's manufacturing sector.

3.0 RESEARCH METHODOLOGY

3.1 Study area: The study was conducted in Nigeria; the country is situated on the Gulf of Guinea in the sub Saharan Africa. Nigeria lies between 4^0 and 14^0 north of the equator and between longitude 3^0 and 15^0 east of the Greenwich. The country has a total land area of 923,768.622km^2 or about 98.3 million hectares and population of over 140 million (NPC, 2006). Industrial sugarcane is cultivated in commercial quantity in the northern part of the country; and is mostly cultivated in irrigated lands or swampy areas. There are four major sugar producing firms and two sugar refineries in Nigeria (NSDC, 2010). These are, Nigeria Sugar Company at Bacita, Kwara State established in 1964 with initial installed capacity of 40,000tons/annum; Savannah Sugar Company Limited at Numan, Adamawa State established in 1980 with initial installed capacity of 65,000tons/annum; Lafiaji Sugar Company in Kwara State and Sunti Sugar Company in Niger State are mini sugar plants. The refineries are BUA and Dangote sugar refineries located in Lagos state. The refineries are not involved in direct production of sugar, but refined semi processed sugar imported from Brazil and other sugar producing countries (NSDC, 2010).

3.2 Data Source: Two major sugar producing firms were purposely selected for data collection. This was because the firms depend fully on the domestic sugarcane for the production of sugar and produced more than 95 percent of domestic produced sugar in the country (NSDC, 2010). The macro economic data used in the study came from publications of Central Bank of Nigeria (CBN), Food and Agricultural Organization (FAO), National Bureau of Statistics, Federal Ministry of Finance and Federal Ministry of labour and Productivity as well as the Federal Ministry of Agriculture and Rural Development. The data collected covered the period 1970 to 2010.

3.3 Analytical Techniques: The empirical model was specified based on the objective of the study. Following Battese and Coelli (1995), firm's stochastic production function (SPF) was defined as:

$$Y_j = (X_j;\beta)exp(V_j - U_j) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where Y_j is the output of j firm, X_j is a vector of factor inputs, V_j is the stochastic error term and U_j is a one sided error representing the technical inefficiency of firm j. Both V_j and U_j are assumed to be independently and identically distributed with constant variance and zero mean.

Technical efficiency (TE) of a firm using Stochastic Production Frontier is given as;

$$TE = \frac{SO_t}{SO_t^*} = \frac{Observed\ Output}{Frontier\ Output} = \frac{f(X_j;\beta)exp(V_j - U_J)}{f(X_j;\beta)exp(V_j)} = exp(-U_j)_1 \ldots\ldots\ldots (2)$$

$$TE = exp(-U_j)_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The technical efficiency index in sugar production, presented in equation (2) was estimated from the sugar stochastic production function of equation presented in log-linear form as:

$$\boldsymbol{In}SO_t = a_0 + a_1\boldsymbol{Ln}INW_t + a_2\boldsymbol{Ln}KS_t + a_3\boldsymbol{Ln}LA_t + a_4\boldsymbol{Ln}DSC_t + a_5\boldsymbol{Ln}EC_t + a_6\boldsymbol{Ln}FAS_t + a_7\boldsymbol{Ln}QOI_t + a_8\boldsymbol{Ln}TEP_t + V_j - U_j \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where:

SO_t = actual output of sugar (tonnes),

SO_t* = stochastic frontier output of sugar (tonnes),

INW_t = non-production labour force employed in production (number of persons) $(SO_t/\delta INW_t > 0)$

KS_t = capital utilization proxy by rate of labour employment in sugar industry (number of persons) $(\delta SO_t/\delta KS_t > 0)$

LA_t = production labour input, measured by the number of production workers employed $(\delta SO_t/\delta LA_t > 0)$

DSC_t = domestic produced sugarcane used as input in the industry (tonnes) $(\delta SO_t/\delta DSC_t > 0)$

EC_t = energy consumption, proxy by annual expenditure on energy (₦/KW) $(\delta SO_t/\delta EC_t > 0)$

FAS_t = sugarcane farm size (ha) $(\delta SO_t/\delta FAS_t > 0)$

QOI_t = quantity of other inputs used in sugar production (tonnes) $(\delta SO_t/\delta QOI_t > 0)$

TEP_t = technological progress captured by time trend $(\delta SO_t/\delta TEP_t > 0)$

3.4 Determinants of Technical Efficiency in Sugar industry in Nigeria.

To determine factors that influence technical efficiency in sugar industry in Nigeria, efficiency equation model was specified as in equation *(5)* (Alam and Morrison, 2000; Njikam, 2000; Badunenko, 2004 and Adewuji, 2006). A dummy variable (D) was introduced into equation *(5)* to capture policy impact on technical efficiency in sugar industry in Nigeria (Adewuyi, 2006).

$$TE = \eta_0 + \eta_1 SIMP_t + \eta_2 INFLA_t + \eta_3 SG_t + \eta_4 ERT_t + \eta_5 RER_t + \eta_6 FS_t + \eta_7 K_t/LA_t + \eta_8 GGDP_t + \eta_9 OTR_t + \eta_{10} PXR_t + \eta_{11} HC_t + \eta_{12} CUR_t + \eta_{13} RWS_t + \eta_{14} D + U_t \quad \ldots\ldots\ldots\ldots (5)$$

Where,

TE = technical efficiency of sugar industry in Nigeria

$SIMP_t$ = real sugar import (₦m)

$INFL_t$ = inflation rate (%)

SG_t = sales growth (proxy by output growth in %)

ERT_t = real expenditure on research and training in the sugar industry (₦m)

RER_t = real exchange rate (₦/$)

RWS_t = average real wage of skilled workers (₦/skilled worker)

FS_t = firm size proxy by sugar industry's employment growth rate (%)

K_t/LA_t = capital-labour ratio (real capital to labour) (₦/worker)

$GGDP_t$ = growth rate of real GDP per capita (%)

OTR_t = official tariff rate on sugar imports (%)

PXR_t = parallel market exchange rate premium (measured as the ratio of the official exchange rate to parallel market rate)

HC_t = human capital (number of skilled and unskilled workers)

ECUR = economic capacity utilization rate in sugar industry (%)

D= dummy variable which takes the value 1 during liberalization period (1986-2010) and 0 otherwise (1970-1985))

U_t = Stochastic error term.

ŋ's are coefficients.

Note: "Economic capacity utilization rate for the industry (ECUR) was estimated independently using cost function approach and injected into this analysis as a variable in equation 5. Also index of annual technical efficiency in the industry was estimated using frontier 4.1 software". PC-Give 10 econometric software was used to estimate the technical efficiency equations. As shown in Battese and Broca (1997), for the distribution assumptions made about random term (μ_i), the elasticity of technical efficiency with respect to a given explanatory variable describe in equation 5 is given by:

$$\left\{\frac{1}{\sigma_u}\left[\frac{\varphi\left(\frac{\mu_i}{\sigma_u}-\sigma_u\right)}{\phi\left(\frac{\mu_i}{\sigma_u}-\sigma_u\right)}-\frac{\varphi\left(\frac{\mu_i}{\sigma_u}\right)}{\phi\left(\frac{\mu_i}{\sigma_u}\right)}-1\right]\right\}\frac{\delta\mu_i}{\delta InX_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(6)$$

Where $\phi(.)$ and $\phi(.)$ are density and distribution function of a standard normal variable respectively. X's are independent variables describe in equation 5. The elasticity was estimated for each explanatory variable describe in equation 5.

3.5 Estimation techniques: Equations (4) was estimated by using the Maximum Likelihood method, while equation *(5)* was estimated using Ordinary Least Squares method. The Augmented Dicker Fuller test (ADF) was used to determine the time series properties of the variables

4.0 RESULTS AND DISCUSSION

The Augmented Dicker Fuller test (ADF) was carried out to determine the time series properties of variables used in the analysis. It was discovered that some series were stationary at level while some were not. Variables in equation 4 were specified at level to avoid the tendency of having negative production variables. In equation 5, since the dependent variable (technical efficiency) was stationary at level and some explanatory variables, it implies that equations (5) could be estimated at level of the variables without the risk of obtaining spurious regressions. Results of the test are shown in Table 5 and 6 in the appendix.

Maximum likelihood estimates of the Cobb-Douglas stochastic production function for the sugar industry as defined in equation (4) *is* presented in Table 2. The result yielded significant sigma squared coefficients of 0.0087 at 5% level. This implies that the models have good fit and that the assumption of the composite error term for the models was correct. The variance or gamma ratios (λ) indicated the proportion of variations in the sugar output that is due to deviation from the technical efficiencies. The gamma ratio of 0.9132 suggests that about 91.32% of variations in the sugar output were due to changes in technical efficiency. The generalized likelihood ratio test was highly significant and this confirms the presence of one - sided error component in the composite error term. Therefore, the results of the diagnostic test confirmed the relevance of the stochastic parametric production function and maximum likelihood estimation method.

Table 2: Maximum Likelihood estimates of Cobb-Douglas Stochastic Production Function for Sugar Industry in Nigeria

Variable	Coefficients	t-value
Constant	-0.5552	-0.154
Non production workers (INW_t)	0.2292	0.165*
Capital Stock (KS_t)	-0.6728	-0.553
Land size (FAS_t)	0.2498	3.102***
Production workers (LA_t)	0.2157	0.138
Qty. of sugarcane (DSC_t)	0.6664	2.149*
Expenditure on energy (EC_t)	0.4108	0.149
Qty. of other inputs (QOI_t)	0.3820	0.222
Technology progress (TEP_t)	0.2587	2.401**
Sigma square Gamma (δ^2)	0.0087 (2.4507)**	
Gamma (λ)	0.5472 (2.8676)**	
Log-Likelihood	0.3804	
LR Test	10.9286	

Note: Asterisk *, ** and ** represent 10%, 5% and 1% significance levels respectively. Variables are as defined in equations *(4).*

The empirical result revealed that non-production workers (INW_t), land size (FAS_t), quantity of sugarcane (DSC_t), and technology (TEP_t) are important production inputs that affect the quantity of sugar produced in the sugar industry in Nigeria. The result also reveals that sugar output is inelastic to the inputs used in the industry. Furthermore, the scale co-efficient is 1.7398 signifying increasing returns to scale of sugar production. It also shows that sugar production is in stage I (irrational stage) in a classical production surface. This implies that more factors of production should be injected in the industry to optimize output and ensure efficient utilization of resources.

4.1 For estimated indices of technical efficiency: In all observations, the index of technical efficiency was less than unity with an average value of 50.80%. This implies that the industry technical efficiency could be increase by 49.20% given the present level of technology and resource endowment of the industry. This means that there was an investment need on factors of production in the industry. This further suggests that the industry lacks sufficient production inputs to achieve optimum or frontier technical efficiency. Figure 1 in the appendix shows the graphical representation of the trend in the technical efficiency indices of sugar industry in Nigeria for the period 1970 to 2010. The graph reveals an average negative trend throughout the study period.

4.2 Determinants of Technical Efficiency in Sugar Industry in Nigeria

Various functional forms of technical efficiency equation were estimated using the specified variables in equation *(5).* Based on the result of the diagnostic tests and the number of significant variables in each functional form as shown in Table 3; the linear form was picked as the lead equation. For the lead equation, the value of the R^2 shows that about 80.40% of variations in the technical efficiency indices were caused by the specified independent variables. The F- statistic of 7.33 was highly significant at 1 percent level and this attested to the overall significant of R^2 and the regression equation. The Durbin-Watson value of 2.05 for the lead equation indicates that autocorrelation was not a problem.

Table 3: Technical efficiency equations in sugar industry in Nigeria

Variable	Linear (L)	Exponential	Semi-log	Double- log
Constant	0.531 (4.20)***	-0.712 (-2.79)	1.166 (0.24)	-1.602 (-1.14)
$SIMP_t$	-7.54e-008 (-0.09)	-6.26e-007 (-0.38)	-0.019 (-1.47)	-0.040 (-1.49)
$INFL_t$	-0.001 (-1.25)	-0.002 (-1.13)	-0.041 (-2.20)**	-0.083 (-2.16)**
SG_t	0.001 (2.44)**	0.002 (2.40)**	0.002 (0.49)	0.003 (0.318)
ERT_t	-0.0001 (-0.89)	-0.0002(-0.72)	-0.017 (-1.38)	-0.040 (-1.55)
RER_t	-0.002 (-2.57)**	-0.003 (-2.58)**	-0.027 (-1.54)	-0.053 (-1.46)
RWS_t	-6.64e-005 (-0.38)	-0.0003 (-0.79)	-0.050 (-1.07)	-0.105 (-1.10)
FS_t	-4.45e-007 (-0.004)	3.12e-005 (0.14)	0.002 (-1.40)	-0.003 (-1.13)
Kt/L_t	4.87e-008(5.00)***	1.00e-007 (5.11)***	0.066 (3.81)***	0.134 (3.18)***
$GGDP_t$	-2.60e-005 (-0.19)	-7.92e-005 (-0.29)	-0.001 (-0.72)	-0.004 (-0.86)
OTR_t	0.002 (2.56)**	0.005 (2.42)**	0.057 (2.29)**	0.113 (2.21)**
PXR_t	-0.023 (-0.27)	-0.008 (-0.05)	0.007 (0.15)	0.014 (0.15)
HC_t	6.84e-006 (0.59)	1.67e-005 (0.20)	0.025 (0.34)	0.085 (0.57)
$ECUR_t$	0.0239 (0.17)	0.380 (0.99)	0.246 (1.72)*	0.525 (1.79)*
D_1	-0.144 (-3.77)***	-0.274 (-3.57)***	-0.117 (-1.45)	-0.226 (-1.36)
R^2	0.804	0.804	0.756	0.748
F-Statistic	7.333***	7.328***	5.528***	5.309***
DW-test	2.05	2.13	2.16	2.16
Normality test	0.906 (0.0063)***	3.496 (0.1741)	0.799 (0.6708)	1.246 (0.5364)
Hetero-test	21.690 (0.7530)	28.066 (0.4076)	32.836 (0.2025)	32.498 (0.2141)
RESET –test	3.896 (0.0600)*	1.099 (0.3050)	0.706 (0.4092)	2.743 (0.1107)

Note: Asterisk * and ** represent 5% and 1% significance level respectively. Variables are as defined in equation *(5).* L means lead equation.

The result shows that, technical efficiency had a significant positive relationship with sales growth (SG_t) in the sugar industry. The finding entails that technical efficiency index increases as sales growth in the industry increases. This implies that 1% increase in sales growth will increase technical efficiency by 0.001%. Badunenko and Adrease (2004) in Germany obtained similar sign in the coefficient of sales growth, but the variable was not significant.

Technical efficiency in the sugar industry in Nigeria had a significant negative relationship with the real exchange rate of naira for US dollar (RER_t). This means that technical efficiency in the sugar industry decreases as the rate of exchange of naira for dollar increases. Alternatively the result implies that technical efficiency in the sugar industry would increase as naira appreciates against US dollar. For instance, a unit increase in the real exchange rate of naira for US dollar will lead to 0.002 units decrease in technical efficiency of sugar industry in Nigeria. The result corroborates the finding of Adewuyi (2006) in Nigeria.

The coefficient of capital-labour ratio (K_t/L_t) was significant and positive at 1 percent probability level, implying that technical efficiency had a direct relationship with capital-labour ratio of the industry. This implies that technical efficiency would increase as the capital-labour ratio increases in the industry. This means that

100% increase in capital –labour ratio will lead to 0.00000487% marginal increase in the technical efficiency of the sugar industry in Nigeria. The finding is similar to that obtained by Chirwa (2000) in Malawi and Alvarez and Gustavo (2003) in Chile; but is contrary to the finding of Niringiye (2010) in Uganda and Tanzania.

The result also revealed that the official tariff rate on sugar import (OTR_t) had a significant (at 5% probability level) positive coefficient and this implies that technical efficiency in the sugar industry in Nigeria has a positive relationship with the official tariff rate on sugar import. This means that technical efficiency would increase as the official tariff rate charge on sugar import increases. For instance, 10% increase in the tariff rate on sugar import in Nigeria will increase technical efficiency of domestic sugar production by 0.02%. The sign of the coefficient is as expected, as increase in tariff rate is expected to stimulate domestic sugar production especially when effective demand is increasing due to increase in price of imported sugar. Njikam (2000) obtained similar result in Cameroon.

The slope coefficient of liberalization policy period (D_1) exerted a significant (at 1 percent probability level) negative effect on the technical efficiency of sugar industry in Nigeria. The finding suggests that the industrial policy of privatization and commercialization which was the major component of the liberalization policy decreases technical efficiency in the industry. It could be infer that the policy retards investment in the sub-sector due to inability of the co-investors to revitalize the sub sector fully. However, the finding contradict the results reported by Ray (2003) in India; Adewuyi (2006) in Nigeria and Chu and Kaliappa (2010) in Vietnam.

4.3 Assessment of the performance of Sugar Industry in import Substitution and liberalization periods in Nigeria

In assessing the performance of the sugar industry in the industrial policy periods in Nigeria, indices of technical efficiency was descriptively analyzed and compared during the period of import substitution and period of liberalization.

Table 4: Comparing Technical Efficiency in the Sugar Industry during periods of Import Substitution and Liberalization in Nigeria.

Indicators	Import substitution Period (1971─1985)	Liberalization Period (1986 ─2010)
Minimum value (%)	49.14	29.36
Maximum value (%)	73.34	65.54
Mean value (%)	61.87	49.00
Coefficient of variability (%)	11.82	18.68
Excess efficiency (%)	38.13	51.00
Average growth rate (%)	1.97	0.58

Source: Computed by the author from the analysis data.

The result of the descriptive tests in presented in Table (4) revealed that the mean technical efficiency in the sugar industry in Nigeria during the import-substitution period was greater than the liberalization period. This implies that the annual index of technical efficiency declines during years of liberalization. The trend in the technical efficiency shows less fluctuation during the period of import-substitution compared to the period of liberalization. This is evident in the lower coefficient of variability (11.82%) in indices of technical efficiency during the period of substitution against high coefficient of variability (18.67%) during the liberalization period. Comparing the values of excess technical efficiency in the sub-periods, the index of technical efficiency was closer to the frontier efficiency during period of import-substitution than period of liberalization. This means that, the sugar industry was more efficient in resource utilization during the period of import-substitution than the period of liberalization. This is evident in the higher growth rate in the technical efficiency during period of import-substitution against lower growth rate during liberalization period. This implies that the industrial policy during the import-substitution period had impacted more on the sugar industry technical efficiency than during the liberalization policy period. Ogun (1987) and Soludo and Adenikinju, (1996) have reported similar results on the manufacturing sector in Nigeria.

5.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS

The study used sugar industry based data and macro-economic data from 1970 to 2010 to analyze technical efficiency in the sugar industry in Nigeria. The descriptive analysis of the technical efficiency indices in the industry revealed that the indices exhibited undulating trend that was fairly downward trend throughout the study period. The indices had an average value of 50.80% and excess technical efficiency rate 49.20%. The empirical results revealed that technical efficiency in the sugar industry had significant positive correlation with the industry's sales growth, capital-labour ratio and official tariff rate on sugar import; while real exchange rate and liberalization policy period have significant negative influence on the technical efficiency of the industry. To increase technical efficiency of resource use in the sugar industry, a restrictive policy measure on sugar imports through periodic review of tariff rate and quantity restriction on sugar import is strongly advocated. Also, a special policy instrument under the deregulation of exchange rate context should be set up to specifically address the issue of foreign exchange constraint to genuine industrialists in the sugar industry. In addition, capital intensive method of production should be adopted as a means of promoting efficiency of resource use in the industry. Furthermore, effective marketing policy on the industry manufactures is strongly recommended. Finally, the industrial policy package for the industry during import substitution period should be used as a benchmark policy to promote technical efficiency in the sugar sub-sector in Nigeria.

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APPENDIX

Table 5: Th**e** Result of Augmented Dicker Fuller Unit Root Test for Variables in equation 4

Logged Variables	level	1^{st} diff	OOIN
SO_t	- 2.335	- 8.362**	1(1)
INW_t	- 2.464	- 9.123**	1(1)
KS_t	- 7.122**	–	1(0)
FAS_t	- 3.240	- 8.262**	1(1)
LA_t	- 2.235	- 8.471**	1(1)
DSC_t	- 3.527*	–	1(0)
EC_t	- 1.776	- 6.125**	1(1)
QOI_t	- 2.425	- 8.125**	1(1)

Note: At level, critical value at 5% = -3.52, and at 1% = - 4.20; at first difference, critical value at 5% = -3.53 and at 1% = -4.21. Asterisks * and ** represent 5% and 1% significance levels respectively. OOIN means order of integration. Variables are as defined in equations *(4).* These tests were performed by including drift and a deterministic trend in the regressions.

Table 6: The Result of Augmented Dicker Fuller Unit Root Test for Variables in equation 5

Variables	**Logged variables**			**Non-logged variables**		
	level	1^{st} diff	OOIN	level	1^{st} diff	OOIN
TE	- 6.558**	–	1(0)	- 6.631**	–	1(0)
$SIMP_t$	- 2.332	- 7.260**	1(1)	- 2.033	- 5.856**	1(1)
SG_t	- 7.361**	–	1(0)	- 6.851**	–	1(0)
ERT_t	- 1.497	- 6.844**	1(1)	- 2.843	- 9.244**	1(1)
RWS_t	- 2.176	- 8.877**	1(1)	- 2.397	- 8.523**	1(1)
FS_t	- 7.145**	–	1(0)	- 5.483**	–	1(0)
Kt/LA_t	- 5.212**	–	1(0)	- 3.779*	–	1(0)
$GGDP_t$	- 6.368**	–	1(0)	- 6.461**	–	1(0)
OTR_t	- 1.456	- 4.988**	1(1)	- 1.866	- 5.651**	1(1)
PXR_t	-1.932	- 6.303**	1(1)	-1.947	- 6.780**	1(1)
HC_t	- 1.646	- 6.610**	1(1)	- 1.736	- 5.434**	1(1)
$INFL_t$	- 3.849*	–	1(0)	-3.321	- 6.204**	1(1)
RER_t	- 1.884	- 4.352**	1(1)	- 0.964	- 5.404**	1(1)
ECUR	- 3.764*	–	1(0)	- 4.028*	–	1(0)

Note: At level, critical value at 5% = -3.52, and at 1% = - 4.20; at first difference, critical value at 5% = -3.53 and at 1% = -4.21. Asterisks * and ** represent 5% and 1% significance levels respectively. Variables are as defined in equations *(5).* OOIN means order of integration. These tests were performed by including drift and a deterministic trend in the regressions.

Figure 1: Trend in Technical Efficiency Indices in Sugar Industry in Nigeria