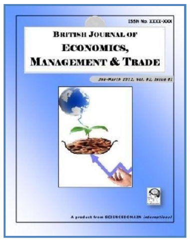


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# Analysis of the Physical Capacity Utilization in the Sugar Industry in Nigeria

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author SBA designed the study, performed the econometric and statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors ODA, SJU and DEJ managed the literature searches and recommendations as well as proof reading of the entire manuscript. All authors read and approved the final manuscript.*

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## ABSTRACT

The study analyzed the physical capacity utilization rates in the sugar industry in the period 1970 to 2010 in Nigeria. Secondary data were obtained from the sugar firms, Central Bank of Nigeria, National Bureau of Statistics and Federal Ministry of Finance. Stochastic Cobb-Douglas production functions for the sugar industry were estimated from which indices of physical capacity utilization rates were obtained. Factors which affect the physical capacity utilization of the industry were investigated. Empirical results revealed that the physical capacity utilization rates in the sugar industry was influenced by the industry's labour productivity, per capita real GDP, sugar import, federal government expenditure on the sugar industry and the quantity of domestic sugarcane used in sugar production. The result of the regression further revealed that the sugar industry in Nigeria was demand unconstrained but resource constrained. It is recommended that appropriate policy measure that should aimed at expansionary aggregate demand as a means of promoting capacity utilization in the sugar industry should be introduced. Such policy measure should be designed to avoid inflationary tendencies. A restrictive policy measure on sugar imports should be adopted in the country. Researches should be intensified to

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develop good hybrids of industrial sugarcane and indigenous technology in sugar production. In addition, there are needs to widen the scope of the National Sugar Development Council and implementation of enhanced welfare packages for workers in the industry.

*Keywords: Sugar; capacity; physical; utilization; industry; efficiency; Nigeria.*

## 1. INTRODUCTION

The sugar sub-sector in the Nigerian economy has contributed to the development of the nation as a whole [16]. The importance of the sub-sector is derived from its contribution to employment and food self sufficiency and its impact on the rural economy in the country [36,2,3]. Sugar is an important food item and also a critical raw material in food, beverage and pharmaceutical industries. In Nigeria, the demand for direct household consumption of sugar remains firm; while the soft drink production alone accounts for about half of the total industrial sugar usage in Nigeria [32]. According to reports by the Central Bank of Nigeria [9] and National Sugar Development Council of Nigeria [34], the current domestic consumption of sugar in Nigeria is in excess of one million five hundred thousand tonnes per annum. Domestic production of sugar in the country had suffered considerably in the past years. For instance, the domestic output declined from 51,080 tonnes in the period 1988 to 1990 to 5,597 tonnes in the period 2001 to 2003 [49,37,42] and (Table 1). Currently, domestic production of sugar is slightly less than 5% of the country's annual requirement [9,34].

From 2000 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 (Table 1). The dismal performance of the sub-sector had been attributed to multifarious factors including inadequate supply of sugarcane to factories, few operating sugar factories, deteriorating capacity utilization in the sub-sector, myriad of factory and field production problems and lack of improved indigenous sugar production technology as well as inadequate domestic private investments in the sub sector [29,49].

Due to the importance of sugar in the Nigerian economy, the two integrated sugar plants at Bacita in Kwara state and Numan in Adamawa state were established in 1961 and 1977 respectively; following the adoption of the import substitution industrialization policy in the country [22]. The aims were to encourage technological development, reduced the volume of imports and encouraged foreign exchange savings by producing locally some of the imported consumer goods [5,12]. The two sugar plants had a combined installed capacity of 105,000 tonnes per annum or less than 10% of the country's annual requirement [34]. Due to some rather complex factors, the major existing sugar companies in the country whose combined installed capacity was expected to climb to 165,000 tonnes per annum after their expansion programme initiated by the federal government in collaboration with African Development Bank and African Development Fund in 1989 and 1991 respectively could not fulfilled the sub-sector's expectation. In the early 1990s, the Nigerian sugar industry was still largely underdeveloped with untapped resources and potentialities. The four existing companies were wholly government owned and were characterized by low productivity occasioned by managerial, financial and infrastructural constraints. In order to accelerate domestic sugar production, the National Sugar Development Council (NSDC) was established in 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 [8,10].

**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 to total output (%) | Share of import to total output (%) |
|---|---|---|---|---|---|---|
| 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: from [42], and [16].*

Also, in Nigeria, most monetary and fiscal policies, among other things, were aimed at achieving full employment of resources and increase capacity utilization in the economy and at the same time curb inflation [4]. In the sugar industry, example of these fiscal policies employed over the years to boost sugar production in the country included 50% tariff on the importation of white sugar, 5% levy on imported raw sugar, free excise duties on sugar production, reduction of import duties on sugar industry machineries, 5–year tax holiday 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 increase the productivity and capacity utilization in the sub-sector. In spite of these measures, Nigeria is still importing more than 90% of its sugar. Nigeria is the largest consumer of sugar in the West African sub-region and second in Africa [2,3]. The country also has a large area of cultivable land, suitable for the growing of industrial sugarcane [8]. Despite the favorable agro-climatic and suitable soil conditions for the production of sugar-cane in addition to the long period of existence of sugar mills; sugar requirements of the country remain largely unmet from domestic sources [37].

One way to understand the dwindling problem in the industry is to study factors that affect capacity utilization in the sub-sector. The study on capacity utilization is a reliable means of measuring the extent of resource use in the firm's production process [50]. It is often used in empirical studies to help explain investment and inventory behaviors, productivity measurement, and indicator of the strength of aggregate demand [25]. A good record of capacity utilization rates in the manufacturing sector have been used to forecast inflationary pressures in developed countries [10,18]. Capacity utilization has an important bearing on the financial performance of any firm and the entire industry. It is widely used in business cycle analysis to characterize the situation of individual industry or the whole economy and to assess the appropriateness of economic policies [11]. In spite of the benefits of capacity utilization rates, there are no reliable data on capacity utilization rates in the sugar industry in Nigeria. Data on manufacturing capacity utilization rates as reported by independent official sources such as the Central Bank of Nigeria (CBN), National Bureau of Statistics and Manufacturing Association of Nigeria etc. are inconsistent with one another and need to be examined to reconcile the discrepancies.

The concept of capacity utilization is broad and could be sub-divided into economic, physical and technology based capacity utilization rate among others. In Nigeria, the issue on physical capacity utilization rates especially in the agro-based industries is relatively new in the literature [13,48,44,1,39]. Most studies on the concept were based on the surveyed opinion of firms related to capacity utilization rate rather than empirical estimation in the individual industry through optimization of the industry's resource endowment [1,41,44]. Other studies based their analyses on data published by the official sources such as Central Bank of Nigeria (CBN) and Manufacturing Association of Nigeria (MAN) with no consideration on capacity utilization estimation procedures [13,48,39].

Therefore, this study differs from the previous ones conducted in Nigeria as it estimated the physical capacity utilization rates for the sugar industry using the sugar industry production data. In addition, it analyzed the factors which influenced the physical capacity utilization rates in the Nigerian sugar industry. Hence, the result of the study is a reliable quantitative fact and source of reference to policy makers to efficiently make relevant policies that can promote the sugar industry's performance in Nigeria. In addition, the results serve as a useful screen board for future analysis of capacity utilization in any sector of the economy. Furthermore, the study provided a frame of reference for agricultural economists,

economists, manufacturers, planners and students who might be carrying out studies on capacity utilization rate of firms.

### 1.1 Factors That Influence Physical Capacity Utilization Rates (PCUR) Among Manufacturing Firms

Relationship between capacity utilization rate (CUR) of firms and other variables have been extensively investigated by many researchers in developed and in some developing economies. Thoumi [46], employed regression analysis to data from 291 firms in Columbia to investigate determinants of the physical capacity utilization rates among firms. He discovered that firm’s capital, market structure, quality of entrepreneur, and firm’s age were the major determinants of the physical capacity utilization rate among firms in the country. Dunlevy [21], discovered a significant positive relationship between capacity utilization rates in the industrial sector and exports in U.S.A. McElthattan [30], investigated the relationship between capacity utilization rate in the industrial sector and inflation rate in U.S.A. she obtained a significant and positive relationship between the two variables. Earlier Franz and Gordon [17] discovered that capacity utilization rate depends more on inflation than on unemployment in both U.S.A and Germany economies. Similar results were obtained by Garner [18]. In India, Goldar and Renganathan [19] and Srinivasan [45], examined the determinants of capacity utilization among industries in the manufacturing sector and found that most of the industries were demand constrained.

Delgado et al. [31], carried out empirical study on the relationship among capacity utilization rate, capital investment, input prices and labor productivity in U.S.A. He used industry data on capital, labor, energy and material for 54 industries. The estimation yielded independent estimates of capacity utilization rates that were positively related to labor productivity, input prices and investment capital. Seth [43], established a positive linked between industrial capacity utilization rate in India and public investment in infrastructures, capital, intermediary import and adoption of liberal policy. Nitsure and Mathew [35], used firm level data from the Indian private corporate sector, to examine the impact of economic reforms on productive capacity creation and utilization across 802 firms for the period 1993 to 1998. The results suggested that substantial achievements occurred initially in the creation and utilization of productive capacities in the various industries. However the results further revealed that, there was significant room for further improvement in productive capacity utilization rates. The results in addition, showed that capital goods import and share of government's current expenditure in the total GDP had significant negative relationship on the productive capacity utilization rate. On the other hand, credit, sales growth, export intensity had positive correlations with the capacity utilization rate of firms. In Bangladesh, Rashid [40] investigated the impact of trade policy reform in 1980s and 1990s on industrial capacity utilization rate and employment generation. Empirical results revealed significant positive impact of the periods on capacity utilization rate and employment capacity. He further stressed that industrial growth was more predominant in export –oriented industries. In Nigeria, Adeel and Simon [1] employed the survey and expert opinion approach to estimate capacity utilization rate among Nigerian firms. They discovered that firm’s capacity utilization rates were affected by the erratic power supply, variations in demand, insufficient capital and insufficient imports and domestic raw materials. Kim [24], analyzed the investment behavior of South Korean manufacturing industries and reported that the sector’s capacity utilization rate was affected by cost of energy, material price, rental price of capital and firm’s output. Goldar and Kumari [20] presented an estimate of capacity utilization rate in India’s industrial sector at the aggregate level covering the period 1981 to 1997. The estimates indicated that there was an upward trend in the capacity utilization rate in the 1980s and downward trend in the period 1990 to 1997. On the other hand, Phillippe and Robin [38] provided evidence of the impact of liberalization policies on the industrial performance in India and UK. Ukoha [48] studied the determinants of the manufacturing capacity utilization rate in Nigeria in the period 1970 – 1988. He employed OLS method on secondary data published by the Central Bank of Nigeria. The result revealed that, the real exchange rate, federal government capital expenditure on the manufacturing sector and the per capita real income had positive effects on the manufacturing capacity utilization rate. On the other hand, the inflation rate and the real loans and advances to the manufacturing sector had negative effects on the capacity utilization rate of the sector. Kumar et al. [28] used time series data from the period 1974 to 2005 to analyze the trends in the capacity utilization rates in the sugar industry in India. The result revealed that, the industry was operating with an excess capacity of 13 percent in each of the study year. The result also showed that, capacity utilization declined during the post reform years, and that the availability of raw materials was the most significant variable explaining the variation in the capacity utilization rate in India's sugar industry.

## 2. THEORETICAL FRAMEWORK

### 2.1 Measurement of the Physical Capacity Utilization Rate

There are various approaches to derive the physical capacity utilization rate of firms. The most widely used approaches are; the ratio of firm's actual output to installed capacity also referred to as the technology based capacity; Peak-to-peak; Production based Data Envelopment Analysis (DEA) and stochastic production.

This study adopted stochastic production frontier methodology to measure the physical capacity utilization rates in the Nigerian sugar industry. Stochastic production frontier indicates the maximum expected output for a given set of inputs. It is derived from the production theory and based on the assumption that output is a function of inputs and the efficiency of the producer in using these inputs. The production frontier assumes that the boundary of the production function is defined by "best practice" firms. It therefore indicates the maximum potential output for a given set of inputs. The difference between observed output and the potential output is generally attributed to a combination of inefficiency and random error. Following Battese and Coelli [6] and Faria [15], Stochastic Production Frontier (SPF) is defined as:

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

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;

$$TE = \frac{Y_j}{Y_j^*} = \frac{Observed\ Output}{Frontier\ Output} = \frac{f(X_j;\beta)exp(V_j - U_j)}{f(X_j;\beta)exp(V_j)} \dots \dots (2)$$

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

While the technique has been developed primarily to estimate efficiency, Kirkley, Morrison and Squires [26] and Tingley and Pascoe [47] have modified the technique to produce estimates of capacity utilization. The original efficiency based Stochastic Production Frontier was modified to represent Technical efficiency capacity utilization (TECU) by incorporating only quasi-fixed inputs of firms into the production function. By excluding variable inputs, the frontier output is determined by efficient use of quasi-fixed inputs. It represents the ratio of actual output to capacity output that could be achieved if all fixed inputs were utilized fully and efficiently.

$$TECU = \frac{Y_j^{+}}{Y_j^{++}} = \frac{Observed\ Output}{Frontier\ Output} = \frac{f(X_j^*;\beta)exp(V_j - U_j)}{f(X_j^*;\beta)exp(V_j)} = exp(-U_j)_2 \ldots\ldots\ldots\ldots\ldots (4)$$

Where $X^*_j$ are only quasi-fixed inputs of j's firm; the capital stock of j's firm is approximated by the rate of man hour employed by the industry [27]. The resulting efficiency score is called technical efficiency capacity utilization (TECU), because it combines both capacity utilization and technical efficiency. However, this is a biased measure of capacity utilization rate, because under normal working conditions; it would be expected that most firms would be operating at less than full efficiency, due at least in part to mis-or unmeasured factors of production [47,14]. To reduce this distortion, an unbiased measure of capacity utilization rate was derived by dividing the technical efficiency capacity utilization rate (TECU) by the efficiency scores estimated in the traditional manner [14], such that;

$$PCUR = \frac{TECU}{TE} = \frac{(-U_j)_2}{(-U_j)_1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where TECU is as defined in equation (4) and TE is the technical efficiency (TE) index computed from the full production relationship (i.e. the contribution of the variable and fixed inputs). Stochastic production frontier (SPF) model has some advantages over other approaches. First, unlike the Peak-to-Peak Approach, Stochastic Production Frontier model can incorporate several independent inputs into firm's production function to generate indices of capacity utilization for a firm. Hence, all available production inputs could be used in the same analysis to produce a single measure of capacity output and utilization. Second, peak-to-peak method and the ratio of firm's actual output to installed capacity approach assume that change in capacity output and utilization is solely due to the technology changes, but Stochastic Production Function relaxes such rigid assumption and assumes that change in capacity utilization is due to inefficiency, technological change and unutilized capacity of a firm. Third, unlike Data Envelopment Analysis approach, the Stochastic Production Frontier is an econometric model that takes into account random variations in data. As such, frontier output is not overestimated. Thus Stochastic Production Frontier (SPF) model produces optimal capacity and utilization rate rather than an average index.

## 2.2 Mathematical Framework

### 2.2.1 Klein capital utilization model

The relationship between capacity utilization rate of a firm and exogenous factors is found in Klein and Preston [27] capital utilization model. In the model, they assume that;

$$\left\{\frac{K_t^f}{K_t}\right\} = \left\{\frac{L_t^f}{L_t}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where, $K_t^f$ and $L_t^f$ are desired capital and manpower levels, while $K_t$ and $L_t$ are actual level of capital and manpower respectively. They also relate firm's output gap to manpower change as thus;

$$\left\{\frac{Y_t}{Y_t^f}\right\} = \left\{\frac{L_t^f}{L_t}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where $Y_t$ is the actual output and $Y_t^f$ is the full employment level of output. Combining equation (6) and (7)

$$\left\{\frac{Y_t}{Y_t^f}\right\} = f\left[\left(\frac{K_t^f}{K_t}\right), \left(\frac{L_t^f}{L_t}\right)\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where the firm output gap, $\left\{\frac{Y_t}{Y_t^f}\right\}$ represents the capacity utilization rate at period "t" [27,23]. Attaching log to both side of the equations and assuming Cobb- Douglas production function;

$$LnY_t - LnY_t^f = LnA_0 + Ln\left({K_t^f}/{K_t}\right)^{\alpha} + Ln\left({L_t^f}/{L_t}\right)^{\beta} + LnZ_t \quad \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Following the flexible investment function;

$I_t = \delta(K^* - K_{t-1})$ Where K* is the desired capital stock. Then

$$K^* = K_t^f = \delta^{-1}(I_t - K_{t-1}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Substituting (10) into (9) will produce;

$$LnY_t - LnY_t^f = LnA_0 + Ln[\delta^{-1}(I_t - k_{t-1})K_t^{-1}]^{\alpha} + Ln\left(L_t^f/L_t\right)^{\beta} + LnZ_t \quad \ldots\ldots\ldots\ldots (11)$$

Also, firm's demand for labour depends on the real wage rate in the economy. Hence at full employment level, wage rate corresponds to $(W/P_0)$, while $(W/P_1)$ corresponds to wage rates below equilibrium level. Thus;

$$\left\{\frac{L_t^f}{L_t}\right\} = \frac{(W/P_0)}{(w/P_1)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

Where "W" is the labour wage and "P" is the general price level in the economy. Substituting equation (12) into (11) produces;

$$LnY_t - LnY_t^f = LnA_0 + Ln[\delta^{-1}(I_t - K_{t-1})K_t^{-1}]^{\alpha} + Ln[(W/P_0)/W/P_1]^{\beta} + LnZ_t \quad \ldots\ldots\ldots (13)$$

$$LnY_t - LnY_t^f = LnA_0 + \alpha[Ln(\delta^{-1}(I_t - K_{t-1})K_t^{-1}] + \beta Ln[(W/P_0)/(W/P_1)] + LnZ_t \ldots \ldots (14)$$

In this framework, output gap defined as capacity utilization rate occurs as a result of the current investment level of a firm, the previous accumulated capital stock and the real wage rate influenced by the general price level in the economy. Their impact on firm output gap or capacity utilization rate is transmitted through factors specific elasticities. This framework assumes that, the output observed in any time period is the equilibrium level for observed rate of utilization of inputs [27]. Hence, other exogenous variables that affect capacity utilization can also be conceptualized in the same manner.

## 3. MATERIALS AND METHODS

### 3.1 study Area

The study was conducted in Nigeria. The country is situated on the Gulf of Guinea in sub Saharan Africa. It lies between 4º and 14º north of the equator and between longitude 3º and 15º east of the Greenwich meridian. Nigeria has a total land area of 923,768.622km$^2$ or about 98.3 million hectares and a population of over 140 million [33]. Industrial sugarcane is cultivated in commercial quantities in the northern part of Nigeria, and is mostly cultivated in irrigated lands or swampy areas. Niger state, Kwara state, and Adamawa state are the major industrial sugarcane producers in the country [29]. There are four major sugar producing firms and two sugar refineries in Nigeria. These are; Nigeria Sugar Company at Bacita, Kwara State established in 1964 with the initial installed capacity of 40,000tons/annum; Savannah Sugar Company Limited at Numan, Adamawa State established in 1980 with the initial installed capacity of 65,000tons/annum; Lafiaji Sugar Company in Kwara State and Sunti Sugar Company in Niger State. The last two are mini sugar plants. The refineries are BUA and Dangote, located in Lagos state. The refineries are not involved in direct production, but refined imported semi processed sugar from Brazil and other sugar producing countries [34]. Following the privatization and commercialization policy under the 2003-2007 reform agenda of the federal government; Savannah Sugar Company was taken over by Dangote in 2002; Nigeria Sugar Company was acquired by Josepdam & Sons in 2006; Lafiaji Sugar Company was bought by BUA Group in 2008 and Sunti Sugar Company was acquired by Flour Mills Nigeria in 2009.

### 3.2 Data Source

Data used in the study were purposely collected from the two sugar producing firms in Nigeria. These firms depended fully on the domestic industrial sugarcane for the production of sugar and produced more than 95 percent of domestic produced sugar in the country [34]. Also, macro economic data published by the Central Bank of Nigeria (CBN), National Bureau of Statistics (NBS), Federal Ministries of Finance, Federal Ministry of Agriculture and Rural Development as well as labour and Productivity were used in the analysis. The sugar firms selected were; Bacita Sugar Company in Kwara state and Savanna Sugar Company in Adamawa state. The data collected covered the period of 1970 to 2010.

### 3.3 Analytical Techniques

The empirical models were specified based on the objective of the study. The estimation of the technical efficiency (TE), technical efficiency capacity utilization rate (TECUR) and the physical capacity utilization rate (PCUR) followed this process:

$$i.e. \quad TE = \frac{SO_t}{SO_t^*} = \frac{f(X_j;\beta)exp(V_j - U_J)}{f(X_j;\beta)exp(V_j)} = exp(-U_j)_1 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (15)$$

The technical efficiency index in the sugar production, presented in equation (2) was estimated from the sugar stochastic production function of equation (16) presented in log-linear as:

$$\boldsymbol{In}SO_t = a_0 + a_1\boldsymbol{Ln}INW_t + a_2\boldsymbol{Ln}KS_t + a_3\boldsymbol{Ln}LA_t + a_4\boldsymbol{Ln}DSC_t + a_5\boldsymbol{Ln}EC_t + a_6\boldsymbol{Ln}FAS_t + a_7\boldsymbol{Ln}QOI_t + a_8\boldsymbol{Ln}TEP_t + V_j - U_j \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (16)$$

Where:

$SO_t$ = actual or gross output of sugar from the sample sugar industry (tonnes),
$SO_t$* = 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 the 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, proxies 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 $(\delta SO_t/\delta TEP_t > 0)$

Furthermore, in line with the equation (4), the technical efficiency capacity utilization rate (TECU) was given by;

$$TECU = \frac{SO_t}{SO_t^*} = \frac{f(X_t^*;\beta)exp(V_j - U_j)}{f(X_t^*;\beta)exp(V_j)} = exp(-U_j)_2 \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (17)$$

Where $X^*_j$ are quasi-fixed inputs of j's firm. $SO_t$ and $SO_t^*$ are the actual and frontier sugar output respectively realized by using only quasi-fixed inputs in the production functions, and on the assumption of optimum used of variable inputs.

The technical efficiency capacity utilization rate, presented in equation *(4)* was estimated using the following log-linear form of the stochastic frontier equation containing only quasi-fixed inputs of the industry:

$$LnSO_t = b_0 + b_1LnINW_t + b_2LnKS_t + b_3LnFAS_t + b_4LnTEP_t + V_j - U_j \ldots \ldots \ldots \ldots \ldots . \ldots . (18)$$

{The variables have the same meaning as in equations *(16)*}.

Finally the physical capacity utilization (PCUR) was computed from the following relationship:

$$PCUR = \frac{TECU}{TE} = \frac{exp(-U_j)_2}{exp(-U_j)_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (19)$$

To analyze the main objective of the study, capacity utilization rate equation model for the sugar industry in Nigeria was specified based on previous studies by [46,48,7]. Dummy variable (D) was introduced into equation (20) to capture the industrial policy impact on the physical capacity utilization rates of the industry [46,48].

Where;

$$CUR_t = \gamma_0 + \gamma_1 INFL_t + \gamma_2 PDSC_t + \gamma_3 LAP_t + \gamma_4 RER_t + \gamma_5 PGDP_t + \gamma_6 EC_t + \gamma_7 LOA_t + \gamma_8 SIM_t + \gamma_9 FCA_t + \gamma_{10} DSC_t + \gamma_{11} D + U_t \quad \ldots\ldots\ldots\ldots\ldots\ldots (20)$$

| | |
|---|---|
| $CUR_t$ = | Physical capacity utilization rate for the sugar industry in Nigeria. |
| $INFL_t$= | inflation rate at period t (%) |
| $PDSC_t$ = | average annual price of domestic sugar cane (₦/tonne) |
| $LAP_t$ = | labour productivity in the sugar industry [defined as total domestic output divided by total number of workers in the sugar industry (tonnes/person)] |
| $RER_t$ = | real exchange rate (₦/$) |
| $PGDP_t$ = | per capita real GDP (2003 =100) (₦) |
| $EC_t$ = | energy consumption proxy by annual expenditure on energy (₦), |
| $LOA_t$ = | real loans and advances to sugar industry (₦) |
| SIMPt/$GDP_t$ = | ratio of sugar import to the GDP (%) |
| $FCA_t$ = | share of Federal Government Capital expenditure on the sugar industry in the GDP |
| $DSC_t$ = | domestic produced sugarcane used as input in the industry (tonnes) |
| D = | dummy variable which takes the value of 1 for the liberalization period (1986-2010), and 0 for otherwise (1970- 1985) |
| $U_t$ = | stochastic error term. |

## 4. RESULTS AND DISCUSSION

### 4.1 Unit Root Test for Variables Used in Equation (20)

Table 2 shows the result of the Augmented Dicker Fuller (ADF) test for logged and non-logged variables defined in equations (20). PC-Give 10 and gretl econometric software's were used to carry out the test. The results revealed that some variables were stationary at level and some at first difference. For both categories, the estimated physical capacity utilization index was stationary at level and first difference. This implies that the nature of the relationship among the specified variables in equation (20) could be determined by multiple regression at the level of the variables provided the diagnostic statistics are satisfactory and showed no evidence of spurious regression (i.e. R2 > D.W) or any econometric problem [51,52].

### 4.2 Estimates of the Physical Capacity Utilization Equation

Table 3 reports the estimates of various forms of physical capacity utilization equations in the Nigerian sugar industry. Following the result of the diagnostic tests and the number of significant independent variables, the double -log form was picked as the lead equation. In the lead equation, the $R^2$ showed that about 63.20% of the variations in the physical capacity utilization rates of the sugar industry in Nigeria (PCUR) were caused by the specified independent variables. The F-statistic is 4.369 and is significant at 1% probability level implying that the estimated $R^2$ is significant and that the model has goodness of fit. The RESET-test is significant at 5% probability level and this indicates that the equation is not mis-specified; meaning that there is significant structural rigidity in the lead equation. The normality test in the lead equation is statistically significant at 1% probability level. This means that the assumption of log linearity among variables is correct and also justifies the use of the Ordinary Least Squires (OLS) estimation method. The Durbin Watson (DW) is greater than $R^2$ in the lead equation; this suggests that the estimated equation is not spurious.

The result revealed that the physical capacity utilization rate (PCUR) in the sugar industry in Nigeria had a significant positive relationship (at 1% level) with the industry's labour productivity ($LAP_t$). The result implies that, the physical capacity utilization rate in the sugar industry in Nigeria had inelastic relationship with respect to the industry's labour productivity. This means that a 10% increase in the labour productivity in the sugar industry would increase the physical capacity utilization rate by 3.0%. It further indicates that the industry could increase physical capacity utilization rate if the rate of increase in output is greater than the rate of increase in the workforce of the industry. The result corroborates the findings of [31].

The result also showed that the physical capacity utilization in the sugar industry had a significant positive association (at 5% level) with the per capita real GDP (PGDPt) in the country. The result implies that increase in PGDPt will increase the physical capacity utilization rate in sugar industry in Nigeria. For instance, a 10% increase in PGDPt will increase the physical capacity utilization rate in the sugar industry by 0.31%. The finding satisfies the a priori expectation as increase in PGDPt is expected to increase the domestic consumption. The implication of this finding is that the sugar industry in Nigeria was not demand constrained. This result implies that the dwindling performance in the sugar industry in Nigeria was not actually caused by demand shortage.

The coefficient of sugar import ($SIMP_t/GDP_t$) exhibited significant positive relationship with the physical capacity utilization rate in the sugar sub-sector. This is contrary to the expected result. The reason could be linked to the internal competition generated in the sub-sector due to increase in the domestic demand for sugar and corresponding increase in sugar imports in the late 1980's to mop up excess domestic demand (NSDC, 2008). This might be substantiated by the fact that, the industry obtained loans from the African Development Fund (ADF) and African Development bank (ADB) in 1989 and 1991 respectively in attempts to increase domestic sugar production in the country. Despite the utilization of the loans and subsequent increase in sugar output in the preceding years, the sugar import also increased due to increased in the domestic demand [9,34].

**Table 2. Result of the unit root test for variables expressed in logarithm**

| Non-Log variable | Level | 1st difference | Order of integration | Log variable | Level | 1st difference | Order of integration |
|---|---|---|---|---|---|---|---|
| $INFL_t$ | -3.321 | -6.204** | 1(1) | $INFL_t$ | -3.849* | - | 1(0) |
| $PDSC_t$ | -0.065 | -6.551** | 1(1) | $PDSC_t$ | -1.950 | -5.259** | 1(1) |
| $LAP_t$ | -4.531*** | - | 1(0) | $LAP_t$ | -4.591** | - | 1(0) |
| $RER_t$ | 0.964 | -5.404** | 1(1) | $RER_t$ | -1.884 | -4.352** | 1(1) |
| $PGDP_t$ | -2.707 | -6.122** | 1(1) | $PGDP_t$ | -1.962 | -6.038** | 1(1) |
| $EC_t$ | -2.936 | -7.943** | 1(1) | $EC_t$ | -1.776 | -6.125** | 1(1) |
| $LOA_t$ | -6.104** | - | 1(0) | $LOA_t$ | -5.939** | - | 1(0) |
| $SIMP/GDP_t$ | -2.161 | -4.949** | 1(1) | $SIMP/GDP_t$ | -2.574 | -6.457** | 1(1) |
| $FCA_t$ | -5.377** | - | 1(0) | $FCA_t$ | -4.716** | - | 1(0) |
| $DSC_t$ | -2.837 | -7.733** | 1(1) | $DSC_t$ | -3.527* | - | 1(0) |
| $CUR_t$ | -4.156* | - | 1(0) | $CUR_t$ | -4.040* | - | 1(0) |
| **Critical values** | | | | | | | |
| 5% | -3.52 | -3.53 | | | -3.52 | -3.53 | |
| 1% | -4.20 | -4.21 | | | -4.20 | -4.21 | |

***Note**: Asterisks *, and ** represent 5% and 1% significance levels respectively. Variables are as defined in equations (20). These tests were performed by including drift and a deterministic trend in the regressions.*

**Table 3. Physical capacity Utilization rate equations for the Nigerian sugar industry (1970-2010)**

| Variable | Linear | Exponential | Semi-log | Double- log(L) |
|---|---|---|---|---|
| Constant | 0.743 (11.40)*** | -0.282 (-3.875)*** | 0.422 (2.41)** | -0.664 (-3.38)*** |
| $INFL_t$ | -2.70 (-0.08) | -1.12e-005 (-0.03) | 0.0009 (0.12) | -0.002 (-0.20) |
| $PDSC_t$ | 1.77e-006 (1.27) | 2.25e-006 (1.44) | 0.007 (0.39) | 0.011 (0.54) |
| $LAP_t$ | 0.009 (2.54)** | 0.010 (2.57)** | 0.262 (3.24)*** | 0.30 (3.27)*** |
| $RER_t$ | -0.001 (-2.60)** | -0.001 (-2.75)** | -0.0158 (-1.42) | -0.020 (-1.58) |
| $PGDP_t$ | 1.24 (0.92) | 1.42e-005 (0.94) | 0.028 (1.93)* | 0.031 (2.39)** |
| $EC_t$ | 2.30e-011 (0.51) | 2.97e-011 (0.59) | -0.006 (-1.04) | -0.007 (-1.02) |
| $LOA_t$ | -5.71e-013 (-0.52) | -5.97e-013 (-0.49) | -0.002 (-1.00) | -0.002 (-0.94) |
| $SIMP_t/GDP_t$ | 0.08 (1.40) | 0.091 (1.37) | 0.018(2.67)** | 0.021 (2.95)*** |
| $FCA_t$ | -6.24 (-0.48) | -7.99e-012 (-0.55) | 0.002 (0.79) | 0.002 (1.75)* |
| $DSC_t$ | -1.19e-007 (-1.30) | -1.38e-007 (-1.35) | -0.041 (-2.14)** | -0.047 (-2.29)** |
| Dummy | -0.03 (-0.90) | -0.041 (-0.97) | 0.010 (0.34) | 0.016 (0.45) |
| $R^2$ | 0.638 | 0.648 | 0.625 | 0.632 |
| F-Statistic | 4.481*** | 4.686*** | 4.24*** | 4.369*** |
| DW-test | 1.70 | 1.65 | 1.45 | 1.45 |
| Normality test | 3.846 (0.146) | 3.139 (0.208) | 10.01(0.006)*** | 10.343(0.005)*** |
| Hetero-test | 0.420 (0.935) | 0.437 (0.926) | 0.545 (0.859) | 0.537 (0.865) |
| RESET –test | 4.814 (0.037)** | 5.296 (0.029)** | 2.332 (0.138) | 3.009 (0.094)* |
| Schwarz Criterion | -141.46 | -132.45 | -140.04 | -130.66 |
| Akaike Criterion | -161.73 | -152.70 | -160.31 | -150.93 |
| Hannan- Quinn C. | -154.41 | -145.39 | -152.98 | -143.59 |
| Loglikelihood | 92.86 | 88.36 | 92.15 | 87.56 |

***Note:*** *Asterisk *, ** and *** represent 10%, 5% and 1% significance levels respectively. Figure in brackets are t-values and variables are as defined in equation (20). L means lead equation.*

The elasticity of physical capacity utilization rate with respect to the share of the federal government capital expenditure in the sugar industry (FCAt) was positive and statistically significant at 10% probability level. The result implies that as the federal government subvention to the sugar industry increases, the physical capacity utilization rate of the industry also increases. For instance, one million naira increase in the federal government subvention to the sub-sector will result in 0.002 gains in physical capacity utilization rate in the industry. The reason for this result might be attributed to the fact that the sub-sector was wholly owned by the federal government before it was privatized in 2003.

The coefficient of quantity of domestic sugarcane used in sugar production ($DCS_t$) was statistically significant at 5% probability level and inversely related to the physical capacity utilization in the sugar industry. The result means that 10% increase in the quantity of domestic sugarcane used in sugar production by the industry will result in 0.47% decrease in the rate of physical capacity utilization. The result might suggests the presence of obsolete technology, poor quality of sugarcane, insufficient quantity of sugarcane or increasing depreciation of the capital stock as well as the deteriorating capacity in the industry. This finding implies that the sugar industry in Nigeria was resource constrained.

## 5. SUMMARY OF FINDINGS

The study used sugar industry based data and macro-economic data from 1970 to 2010 to analyze the physical capacity utilization rates in the sugar industry in Nigeria. The macro-economic data used were inflation rate, exchange rate, GDP, tariff rates on sugar import, consumer price index, parallel and official exchange rates among others. Multiple-regression equation of various forms was estimated based on the ordinary least squares method and used to determine factors that influence the physical capacity utilization rate of the sugar industry in Nigeria. The result of the diagnostic tests and number of significant variables among others were used as criteria for selecting the lead equations. The empirical results revealed that the physical capacity utilization rate in the sugar industry in Nigeria had a significant positive relationship with the industry labour productivity, share of the federal government expenditure on sugar industry in the GDP, per capita real GDP and sugar import. On the other hand, the quantity of domestic sugarcane used in sugar production has significant negative relationship with the physical capacity utilization rates in the industry.

### 5.1 Recommendations

Increase in per capita real GDP increases the capacity utilization rate in the sugar industry in Nigeria. It is recommended that an appropriate policy measure that aim at expansionary aggregate demand as a means of promoting capacity utilization in the sugar industry should be introduced. Such policy measure should be designed to avoid inflationary tendencies. A restrictive policy measure on sugar imports should be adopted in the country such as; periodic review of tariff rates on sugar imports and quantity restriction on sugar import as means of boosting the domestic sugar production and promoting capacity utilization rate in the sugar industry. Researches should be intensified to develop good hybrids of industrial sugarcane and indigenous technology in sugar production. This could be achieved through strengthening the existing sugar research institutes and widening the scope of the NSDC in the country. Incentives and enhanced welfare packages should be initiated to workers in the sub-sector as these will help to improve the productive capacity of the industry.

## 6. CONCLUSION

Achievement of sustained growth in the Nigerian sugar industry could be an important stimulant of economic growth following the forward and backward integration, the industry has with other sectors in the economy. Sugar as an important raw material for many industries, has the potential to influence the country's GDP. The domestic sugar production in Nigeria has been affected by diverse factors ranging from firm related factors to environmental and macro-economic fundamentals. This research has identified some of these factors and also proffers policy recommendations needed to tackle the dwindling physical capacity utilization rates in the industry. Hence, these empirically based policy recommendations are crucial for the needed sustainable growth in the industry in Nigeria. It is hoped that the policy recommendations in this study will guide policy makers on issues related to capacity utilization in the sugar industry and other industries in the manufacturing sector in Nigeria.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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