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Empirical Assessment of Manufacturing Companies Efficiency in Nigeria:Data Envelopment Analysis (DEA) Approach

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Abstract
This study dwells on data envelopment analysis and industry analysis. The study analyzed the technical efficiency of twenty (20) selected manufacturing companies for the period 2015 to 2016 using input and output oriented data envelopment analysis (DEA) approach. Findings arising from the study indicate that 35% of the quoted sampled manufacturing firms in Nigeria were scale efficient while 65% were scale inefficient in the period observed. Thirty percent (30%) of the manufacturing companies on the basis of constant return to scale (CRS) were technically efficient while 70% of them were technically inefficient in the period observed. Forty percent (40%) of the companies in terms of variable return to scale (VRS) were technically efficient while 60% were not technically efficient in the context of variable return to scale. The study concluded that manufacturing firms in Nigeria are not optimally performing with input and output mix of variables. It is therefore recommended that there is need for them to scale down cost of production through appropriate strategic decisions.
Keywords: Technical efficiency, data envelopment analysis, firm performance

1.0 INTRODUCTION

Firms and industries performance and efficiency previously have always been analyzed using financial ratios. As time passes by, the use of ratios was seen as unsuitable in examining efficiency of companies. There was a shift to the use of parametric approach such as the use of stochastic frontier and non- parametric approach like the data envelopment analysis (DEA) to examine firms' efficiency. Overtime, results obtained with the use of these approaches have been quite intriguing and yet mixed and inconclusive based on sample size, variables used, period differential and country specific data. No researchers can meaningfully contribute to the body of knowledge these days in terms of efficiency analysis of companies and industries without the use DEA. According to Qamruzzaman and Jianguo (2016), it is prominent that DEA has a strong appeal among researchers for assessing level of efficiency whether for financial institution or other business areas.

Efficiency assessment of business firms is a major concern by managers and stakeholders in the light of present day global challenges in both developed and developing countries. Efficiency assessment of a company no doubt demonstrates how shareholders and investors interests are taken into consideration. It informs them how a company's resources are used effectively and efficiently and it also motivates firms to implement strategies for further improvements (Yu, Barros, Tsai & Liao, 2014). Yu et al (2014) pointed out that data envelopment analysis (DEA) has proven to be an essential tool because it measures relative efficiencies by using multi-inputs and multi-outputs variables. Data Envelopment Analysis (DEA) has been found to measure efficiency of firms with more precision and lower magnitude of inefficiency than other approaches (Eriki & Osagie, 2014).

Moreover, efficiency is a dynamic concept that involves a firm being able to operate with the minimum level of resources or inputs such as capital, labour, and materials to produce maximum outputs and still remain highly competitive for a considerable period of time (Mosfafa, 2007). Assessing efficiency levels has thus become an important issue for managers of businesses in developing countries like Nigeria that is currently going through economic turbulence. Several methodologies which include scorecards, economic production function, econometric stochastic frontier analysis, multi-attribute decision making techniques and regression analysis have been employed for measuring and assessing business performance but these measures are often inadequate due to multiple inputs and outputs defined by different resources, activities and environmental factors, thus making Data Envelopment Analysis (DEA) becomes a viable alternative (Osamwonyi & Imafidon, 2015).

A firm is regarded as efficient if it is able to employ small costs to generate higher revenue; and on the other hand, a firm is facing inefficiency when it is inefficient in terms of technical and allocative efficiency and that implies it is still not operating at its optimal level (Coeli et al, 2005). The efficiency of firms particularly the firms in the banking sector has been empirically analyzed using data envelopment analysis (DEA). But many studies

have actually not focused on the efficiency of manufacturing companies in developing countries like Nigeria using DEA. The importance of the efficiency of manufacturing firms cannot be overemphasized in an economy. They contribute largely to economic activities; making goods available to consumers via appropriate medium. The manufacturing sector has a great potential in promoting economic growth and competitiveness of a country; albeit, happenings in the economy generally impact on the operation of manufacturing companies. The most frequently cited problems of manufacturing firms in Nigeria include physical infrastructure, followed by access to credit, insufficient demand, and cost of imported raw materials and lack of skilled labour (Soderbom & Teal, 2002). Against this backdrop, this study undertakes data envelopment analysis and industry analysis in Nigeria.

The Nigerian Stock Exchange (2010) indicates that thirty percent of industries were closed down, sixty percent of industries classified as ailing and only ten percent classified as operating at sustainable level. All these indicate that the efficiency of the Nigerian quoted manufacturing companies is in doubt (Osamwonyi & Imafidon, 2016). They opined that various studies have been conducted to measure technical efficiency of manufacturing sector in Nigeria and among these studies are Soludo and Adenikinju (1996), Adenikinju (1996), Chete and Adenikinju (1996). These studies employed aggregate data and panel regression analysis, while those that applied data envelopment analysis (DEA) in assessing the efficiency of manufacturing companies were foreign studies (Osamwonyi & Imafidon, 2016). These studies include Diaz and Sanehcz (2008), Mahedevan (2010), Fare, Grosskopf and Margaritis (2001), Nordin and Said (2010) and Ephraim (2000). In Nigeria, there are very scanty studies that have empirically examined the technical efficiency of quoted manufacturing companies. This study is an attempt to fill this gap. Similarly, the study is a departure from Osamwonyi and Imafidon (2016) in that it seeks to use input and output variables like total assets, fixed assets, operating expense, equity, revenue, gross profit, profit before tax and profit after tax that were hitherto not employed using data envelopment analysis (DEA) with a view to contributing to existing literature. The following research questions are therefore raised with a view to investigating the subject matter.

2.0 LITERARURE REVIEW

2.1 Empirical Review

Osamwonyi and Imafidon (2015) undertook a study of the allocative efficiency of quoted manufacturing companies in Nigeria for the period 2004 – 2010. The study used the output oriented DEA model with four input and output variables. The input variables were total assets; shareholders' equity, cost of goods sold and operating expenses while the output variables were sales / turnover, net profit, return on asset and return on equity. The method used by the researcher assumed variable return to scale assumption using multi-stage DEA. The result obtained indicate that there was inefficient allocation of resources with the presence of high slacks for the input variables such as total asset recording 114%, shareholders' equity (77%), cost of goods sold (47%) and operating expenses (71%) in the production process of quoted manufacturing companies in Nigeria. the study recommended that total asset and shareholder's equity should be depleted from the firms' current allocations and such resources should be shifted to alternative production activities. The result obtained by the researchers regarding the inefficient allocation of resources may not be unconnected with multiple input variables and their copious similarities in terms of relationship statistically. This study is a departure from Osamwonyi and Imafidon (2016) by introducing variant input variables like fixed assets (FA), total asset (TA), operating expenses and equity. The output variables used in this study are revenue, profit before tax, profit after tax and gross profit respectively.

Osamwonyi and Imafidon (2016) empirically examined the technical efficiency of manufacturing companies on the Nigerian Stock Exchange using output oriented data envelopment analysis approach. The analysis revealed that quoted manufacturing companies in Nigeria are efficient with an average variable return to scale mean score of 85% and scale efficiency mean score of 76%. A breakdown of the results shows that thirty – one companies out of the fifty – eight companies set chosen for the study were operating on production possibility frontier while the remaining twenty – seven companies were not. The study did recommended that the companies that are operating in the region of decreasing return to scale should scale down their inputs while those that are in the region of increasing return to scale should scale up their inputs.

Usman, Hassan, Mahmood and Shahid (2014) examined the performance of textile sector of Pakistan through the use of data envelopment analysis principally to measure technical efficiency for the period 2006 to 2011. The finding indicates that Pakistan textile firms are near efficient. Baten, Kamil and Fatama (2009) investigated the technical efficiency of manufacturing firms of Bangladesh. They used stochastic frontier analysis with Cobb-Douglas production function to estimate efficiency and found that output level of half normal distribution was almost 55%. Haran and Chellakumar (2012) analyzed the technical efficiency of manufacturing firms of Kenya. They used Pearson correlation and data envelopment analysis with input orientation to measure efficiency. The study concluded that efficiency of smaller firms with the comparison of medium size and large firms have been greater from 2009 to 2011 for the manufacturing sector of Kenya. Renuka and Kalirajan (2000) study concluded that manufacturing sector of Singapore was not operating its optimal level and it has potential to improve efficiency. Additionally, the result from technical efficiency measurement showed that quality of labour and capital intensity

should be improved to enhance technical efficiency. Wu (2007) performed empirical analysis technical efficiency of individual manufacturing sectors for the comparison among sectors. The study found that rewards to labour and benefits from taxes were more important for the further improvement in efficiency level of manufacturing sectors of China.

Tahir and Yusof (2011) adopted DEA with inputs-oriented assumptions to estimate the technical and scale efficiency of 14 Malaysian public listed companies. Two inputs and one output were used. The inputs employed were total expenses and total assets, and the output was sales revenue. The estimate result disclosed that only one company was relatively efficient.

Joshi and Singh (2009) estimated the production efficiency of the ready-made garment industry using DEA technology. They considered the number of stitching machines and number of operators as inputs-variables and the number of garment pieces produced as output variables. The result revealed that, under constant returns to scale (CRTS), firms should increase their outputs by 25% with the existing level of inputs into desired outputs (Tongzon, 2001).

The performances of the companies in the Turkish textile and apparel industry were evaluated by Kayali (2009) using DEA for several researchers so far in which the input and the output parameters were selected differently. By using input oriented model, the researcher measured technical efficiency, pure technical efficiency and scale efficiency of 29 textile companies among Fortune 500 companies listed in 2007 using number of employees, shareholders' equity and net assets as inputs, and net sales and net profits as outputs. The result of the analyses revealed that efficiency score of textile sector was equal to 57%. The authors indicated that utilization of the resources was inefficient in the sector. Bayrak Ozcan, Anil and Emre (2003-2004) conducted efficiency measurement within 25 textile companies in Istanbul. They used employees, shareholders' equity and net assets as inputs, and turnover, profit before tax and export revenue as outputs. The results revealed that only 5 companies were efficient, and 7 of the rest had an efficiency ratio above 50%, while 13 companies had an efficiency ratio below 50%. Kayalidere and Kargin (2004) investigated the efficiency of companies in the textile and cement sectors that were listed in the Istanbul Stock Exchange in 2002. They performed two analyses. In the first analysis, they used the number of employees and total assets as inputs, and net sales and net profit as the outputs. In the second analysis, number of employees and tangible assets were considered as inputs, and net sales and net profit were considered as the outputs. According to the results, they tried to determine how much inefficient companies should improve their input-output amounts to be efficient and productive compared to the efficient companies in the sector by calculating potential improvement rates. Gozu (2003) analyzed the technical and scale efficiencies of 19 companies for 2001 and 2002 that performed in the textile, leather and apparel industry, quoted by Istanbul Stock Exchange. He used number of employees, tangible assets, paid-in capital and stocks as the inputs, and net sales and net profit as the outputs for the input-oriented DEA model. For the years 2001 and 2002, it was found that average efficiency score was 0.894 and 0.797 in terms of constant return to scale, while it was 0.940 and 0.932 in terms of variable return to scale respectively; and therefore it was concluded that the companies had generally efficient operating cycles for both years. Finally, it was suggested for the companies that were efficient in 2001, but did not have scale efficiency in 2002 to revise their scales, as well as their input and output levels. Duzakin and Duzakin (2007) used super slack based model, which allowed getting a ranking of efficient companies, in order to analyze the performances of the 500 major companies in Turkey and the performances of the industries during 2003. They used net assets and the number of employees as inputs, and profit before tax, export revenues and gross value added as the outputs. They concluded that the textile, apparel and leather industry was weak in terms of profit before taxes, and an increment of 1140.32% were needed. The industry also needed an increase of 176.79% in value added for the year 2003. The reason for inefficiency in the textile, apparel and leather industry was stated as the insufficient seasonal profits. Moreover, Arig (2011), Altin (2010), Yalama and Sayim (2008) measured and evaluated the efficiencies of manufacturing companies, including the companies in the textile, leather and apparel industry, listed in Istanbul Stock Exchange by using financial ratios as input and output variables for different periods. However, they did not evaluate each sector individually which could lead to misleading results due to the different structures of the sectors. In other words, the companies being evaluated should be comparable in terms of business segment in order to perform benchmarking.

3.0 METHODOLOGY

This study uses the descriptive research design. The population of the study is the entire manufacturing firms listed on the floor of the Nigerian Stock Exchange as at 31st December, 2016. The Nigerian Stock Exchange Fact book revealed that there are 102 manufacturing firms quoted in 2016. Twenty percent (20%) of the listed firms were taken as sample size using purposive sampling technique and this represents about 20 companies. Primarily, this study analyzes the technical efficiency of the selected manufacturing companies for the period using data envelopment analysis (DEA).

3.1 Variables Description

This study used input and output variables to determine the efficiency (Technical efficiency) of manufacturing firms in Nigeria. Different set of input variables are commonly used in empirical studies particularly with respect to manufacturing firms. This study uses fixed assets, total assets, operating expenses and equity as input variables while the output variables used are revenue, gross profit and profit before tax profit after tax.

3.2 Model Specification

The efficiency scale score, constant return to scale and variable return to scale models used in this study are adapted from Eriki and Osagie (2014) study on performance efficiency of selected quoted commercial banks in Nigeria (A DEA Approach) and Osamwonyi and Imafidon (2016) study on the technical efficiency of manufacturing companies on the Nigerian Stock Exchange using data envelopment analysis (DEA).

According to Eriki and Osagie (2014) if n firm (as DMU) converts the same m inputs into the same s outputs and the jth firm uses an m-dimension input vector, xij (I = 1, 2; …, m) to produce an s-dimensional output vector, Y_{rj} (r = 1, 2, …, s), and denoting the firm under evaluation by subscript 0, the optimization problem solved for each firm is expressed as;

Maximize $\sum_r U_r Y_{rc} / \sum_{t=1} V_i X_{t0}$ ..... (1)

Subject to the constraints

$\sum_{t=1} V_i X_{ij} \leq 1 \; for \; j = 1, 2, \dots 0$ ..... (2)

$for \; r = 1, 2, \dots s$ ..... (3)

$for \; r = 1, 2, \dots m$ ..... (4)

Where:

U_r.Denote the weighted outputs and V_i denote the inputs weight and both must be non-negative. The sum j is referred to as the virtual (weighted) output. The objective function indicated by h_0 is the ratio of weighted output to weighted inputs, which is the relative efficiency ratio. The maximum value h_0 can assume is 1. If this efficiency score is 1, firm h_0 satisfies the necessary condition to be DEA efficient, otherwise, it is inefficient. This implies that for any group of firm, one or more must be the most efficient (having efficiency score $h_0 = 1$), while others (with efficiency score $h_0 < 1$) will be relatively inefficient compared with the efficient ones.

Furthermore the efficiency scores makes for a ranking of firms in the population from the least efficient to the most efficient. While the most efficient firm(s) must (each) have an efficiency score of unity (i.e 1), the least efficient firm need to have a score of zero (Eriki & Osagie, 2014).

3.3 Constant Returns to Scale Model:

The constant returns to scale model assumes strong disposability of inputs (s) and it determines the amount by which observed inputs can be proportionally decreased if they are utilized efficiency and $OTE_{j0}(y, x/C, S) =$ Min 0 (Osamwonyi & Imafidon, 2016). Where $OTE_{j0}(y, x/C, S)$ is the overall technical efficiency of the firm $_{j0,}$ is the measure of technical efficiency, y_{rj}denotes output r $(r = 1 \dots s)$ for the jth firm, $x_i$denotes input $1 = (i = 1 \dots, m)$ and w_j are the weights used to construct hypothetical firms on the frontier. The relative efficiency here captures the percentage by which observed inputs can be proportionally decreased, given the output, if firms use them efficiently. This is equivalent to measuring the ratio of actual output to potential/efficient (frontier) output (Osamwonyi & Imafidon, 2016).

3.4 Variables Returns to Scale Model

The assumption of constant returns to scale for estimating overall efficiency could be relaxed to obtain efficiency under variable returns to scale (v), while maintaining the assumption of strong disposability of inputs; a linear programming should naturally derive the input orientated weak efficiency measure under variable returns to scale as:$WTF_{j0}(y, x/V, S) =$ Min 0 subject to $\sum_{j=1}^{n} w_j = 1$ (Osamwonyi & Imafidon, 2016).

3.5 Scale Efficiency Model:

Scale efficiency captures departure of a firm from optimal scale. The input orientated scale efficiency measure is given as:

$$STE_{j0}(y, x)) = \frac{OTE_{j0}(y, x/C, S)}{WTE_{j0}(y, x/V, \; S)} j = 1, 2 \dots J$$

Thus, firm j is input scale efficient if $STE_{j0}(y, x) = 1$ or if it is equally technically efficient relative to the (C, S) and (V, S) input set and the scale efficiency measures input loss due to operating at an inefficient scale (Osamwonyi & Imafidon, 2016).

4.0 EMPIRICAL ANALYSIS

Table A: Scale Efficiency Scores of Quoted Manufacturing Firms in Nigeria (2015-2016)

Year	DMU(Companies)	dmu	CRS rank	VRS rank	CRS_TE	VRS_TE	SCALE	REMARK
2016	7Up Nigeria	dmu:1	10	1	0.96	***1.00	0.96	DRS
2016	Aluminium Extrusion Indus	dmu:2	13	13	0.78	0.91	0.86	DRS
2016	Ashaka Cement	dmu:3	20	20	0.40	0.40	0.99	DRS
2016	B.O.C Gases Nig	dmu:4	19	19	0.41	0.41	0.98	DRS
2016	Berger Paints Nig	dmu:5	18	18	0.45	0.45	0.99	DRS
2016	Beta Glass Company	dmu:6	6	10	***1.00	***1.00	***1.00	CRS
2016	Cement Comy Of Northern Nig	dmu:7	16	16	0.62	0.70	0.89	DRS
2016	Champion Breweries	dmu:8	14	14	0.69	0.76	0.91	DRS
2016	Chemical & Allied Product	dmu:9	5	9	***1.00	***1.00	***1.00	CRS
2016	Cutix	dmu:10	1	1	***1.00	***1.00	***1.00	CRS
2016	Dangote Cement	dmu:11	11	1	0.91	***1.00	0.91	DRS
2016	Dangote Sugar	dmu:12	7	11	***1.00	***1.00	***1.00	CRS
2016	Fidson Healthcare	dmu:13	17	17	0.50	0.65	0.77	DRS
2016	First Alumminium Nig	dmu:14	1	1	***1.00	***1.00	***1.00	CRS
2016	Flour Mills Of Nigeria	dmu:15	8	1	***1.00	***1.00	***1.00	CRS
2016	Glaxosmithkline Nig	dmu:16	9	1	***1.00	***1.00	***1.00	CRS
2016	Greif Nig	dmu:17	1	1	***1.00	***1.00	***1.00	CRS
2016	Paints & Coatings Man	dmu:18	12	12	0.85	0.95	0.90	DRS
2016	Unilever Nig	dmu:19	1	1	***1.00	***1.00	***1.00	CRS
2016	Union Diagnostic & Clinical Sev	dmu:20	15	15	0.65	0.71	0.91	DRS
Year	**2015 Company**	**dmu**	**CRS rank**	**VRS rank**	**CRS_TE**	**VRS_TE**	**SCALE**	
2015	7Up Nigeria	dmu:1	11	1	0.75	***1.00	0.75	DRS
2015	Aluminium Extrusion Indus	dmu:2	1	1	***1.00	***1.00	***1.00	CRS
2015	Ashaka Cement	dmu:3	17	17	0.48	0.48	***1.00	CRS
2015	B.O.C Gases Nig	dmu:4	19	19	0.39	0.39	0.99	DRS
2015	Berger Paints Nig	dmu:5	18	18	0.46	0.47	***1.00	CRS
2015	Beta Glass Company	dmu:6	12	13	0.66	0.66	0.99	DRS
2015	Cement Comy Of Northern Nig	dmu:7	13	14	0.62	0.65	0.97	DRS
2015	Champion Breweries	dmu:8	20	20	0.37	0.37	0.99	DRS
2015	Chemical & Allied Product	dmu:9	7	8	***1.00	***1.00	***1.00	CRS
2015	Cutix	dmu:10	10	11	0.86	0.89	0.97	DRS
2015	Dangote Cement	dmu:11	1	1	***1.00	***1.00	***1.00	CRS
2015	Dangote Sugar	dmu:12	1	1	***1.00	***1.00	***1.00	CRS
2015	Fidson Healthcare	dmu:13	15	15	0.52	0.64	0.82	DRS
2015	First Alumminium Nig	dmu:14	1	1	***1.00	***1.00	***1.00	CRS
2015	Flour Mills Of Nigeria	dmu:15	1	1	***1.00	***1.00	***1.00	CRS
2015	Glaxosmithkline Nig	dmu:16	14	10	0.57	0.93	0.61	DRS
2015	Greif Nig	dmu:17	6	7	***1.00	***1.00	***1.00	CRS
2015	Paints & Coatings Man	dmu:18	9	12	***1.00	0.78	***1.29	CRS
2015	Unilever Nig	dmu:19	8	9	***1.00	***1.00	***1.00	CRS
2015	Union Diagnostic & Clinical Sev	dmu:20	16	16	0.50	0.52	0.97	DRS

Where CRS TE is constant return to scale technical efficiency, VRS TE is variable return to technical efficiency, CRS RANK implies constant return to scale ranking while VRS RANK is variable return to scale ranking of the sampled companies in the period observed. The result from the above table A indicates that nine (9) out of the twenty sampled companies had scale efficiency scores of 100% in 2016. These companies include Beta Glass Company, Chemical and Allied, Cutix, Dangote Sugar, First Aluminum Nigeria PLC, Flour Mills of Nigeria, GlaxoSmithKline, Nig. Greif Nigeria PLC and Unilever Nig. In 2015, ten (10) of the manufacturing firms out of the sampled firms had scale efficiency scores of 100%. This means that 45% of the sampled companies are scale efficient and 55% were scale inefficient. Companies that maintained scale efficiency both in the 2016 and 2015 out of the 20 sampled firms were seven (7) representing about 35% while 13, about 65% were scale inefficient. This suggests that the firms' production possibility frontier is efficient in that they can produce their current level of output with fewer inputs given the existing state of knowledge about technology and the organization of production. All other firms experiencing decreasing returns to scale (DRS) are those whose inputs when doubled, the output is less than doubled; hence they are regarded as inefficient. This finding implies that some manufacturing firms are not scale efficient. This may be due to the macro-economic challenges affecting

companies in Nigeria such as the recession and inflation and government policies, the inputs and output variables, sample and period used. The study finding is consistent with Renuka and Kalirajan (2000); Haran and Chellakumin (2012); Usman, Hassan; Mahmood and Shahid (2014); Tahir and Yusot (2014); Kayali (2009), Joshi and Sing (2009). The findings are however contrary to Osamwonyi and Imafidon (2015 and 2016), Gozu (2003); Duzakin and Duzakin (2007). The variant results obtained in this study from that of other prior researchers may be attributable to sample size, sample period, industry, input and output variables differentials.

Table B: The Technical (Constant Return to Scale and Variable Return to Scale) Efficiency Scores of Quoted Manufacturing Firms in Nigeria (2015-2016)

Year	2016 Company	Dmu	CRS_TE	REMARK	VRS_TE	REMARK
2016	7Up Nigeria	dmu:1	0.96	DRS	***1.00	DRS
2016	Aluminium Extrusion Indus	dmu:2	0.78	DRS	0.91	DRS
2016	Ashaka Cement	dmu:3	0.40	IRS	0.40	DRS
2016	B.O.C Gases Nig	dmu:4	0.41	IRS	0.41	DRS
2016	Berger Paints Nig	dmu:5	0.45	IRS	0.45	DRS
2016	Beta Glass Company	dmu:6	***1.00	CRS	***1.00	CRS
2016	Cement Coy Of Northern Nig	dmu:7	0.62	DRS	0.70	DRS
2016	Champion Breweries	dmu:8	0.69	DRS	0.76	DRS
2016	Chemical & Allied Product	dmu:9	***1.00	CRS	***1.00	CRS
2016	Cutix	dmu:10	***1.00	CRS	***1.00	CRS
2016	Dangote Cement	dmu:11	0.91	DRS	***1.00	DRS
2016	Dangote Sugar	dmu:12	***1.00	CRS	***1.00	CRS
2016	Fidson Healthcare	dmu:13	0.50	IRS	0.65	DRS
2016	First Alumminium Nig	dmu:14	***1.00	CRS	***1.00	CRS
2016	Flour Mills Of Nigeria	dmu:15	***1.00	CRS	***1.00	CRS
2016	Glaxosmithkline Nig	dmu:16	***1.00	CRS	***1.00	CRS
2016	Greif Nig	dmu:17	***1.00	CRS	***1.00	CRS
2016	Paints & Coatings Man	dmu:18	0.85	DRS	0.95	DRS
2016	Unilever Nig	dmu:19	***1.00	CRS	***1.00	CRS
2016	Union Diagnostic & Clinical Sev	dmu:20	0.65	DRS	0.71	DRS
Year	**2015 Company**	**dmu**	**CRS_TE**		**VRS_TE**	
2015	7Up Nigeria	dmu:1	0.75	DRS	***1.00	DRS
2015	Aluminium Extrusion Indus	dmu:2	***1.00	CRS	***1.00	CRS
2015	Ashaka Cement	dmu:3	0.48	IRS	0.48	CRS
2015	B.O.C Gases Nig	dmu:4	0.39	IRS	0.39	DRS
2015	Berger Paints Nig	dmu:5	0.46	IRS	0.47	CRS
2015	Beta Glass Company	dmu:6	0.66	DRS	0.66	DRS
2015	Cement Coy Of Northern Nig	dmu:7	0.62	DRS	0.65	DRS
2015	Champion Breweries	dmu:8	0.37	IRS	0.37	DRS
2015	Chemical & Allied Product	dmu:9	***1.00	CRS	***1.00	CRS
2015	Cutix	dmu:10	0.86	DRS	0.89	DRS
2015	Dangote Cement	dmu:11	***1.00	CRS	***1.00	CRS
2015	Dangote Sugar	dmu:12	***1.00	CRS	***1.00	CRS
2015	Fidson Healthcare	dmu:13	0.52	IRS	0.64	DRS
2015	First Alumminium Nig	dmu:14	***1.00	CRS	***1.00	CRS
2015	Flour Mills Of Nigeria	dmu:15	***1.00	CRS	***1.00	CRS
2015	Glaxosmithkline Nig	dmu:16	0.57	IRS	0.93	DRS
2015	Greif Nig	dmu:17	***1.00	CRS	***1.00	CRS
2015	Paints & Coatings Man	dmu:18	***1.00	CRS	0.78	CRS
2015	Unilever Nig	dmu:19	***1.00	CRS	***1.00	CRS
2015	Union Diagnostic & Clinical Sev	dmu:20	0.50	IRS	0.52	DRS

The table B above indicates variable return to scale (VRS) and constant return to scale; and VRS implies increase in input variables by 1% can lead to a more than 1% increase in output is analyzed. The VRS DEA results above revealed that eleven (11) of the firms are able to through a percentage increase in input increase the output by more than proportional. This represents 55% technical efficiency score in 2016 while only 9 of them experienced variable return to scale in 2015, representing 45%, while 45% were inefficient in 2016; 55% operated below efficiency. In the period observed, the 40% of the firms were technically efficient on the basis of variable return to scale while 60% were technically inefficient. The technical efficiency scores of the 20 sampled

manufacturing firms based on constant return to scale (CRS) DEA model (CRSTE) shows that only nine (9) were efficient in 2016 and 2015 respectively. Those manufacturing companies that used their inputs (total assets, fixed assets, operating expenses and equity) to generate better outputs (revenue, gross profits, profit before tax and profit after tax) in 2016. are Beta Glass company, chemical and allied product plc, Cutix Nigeria Plc, Dangote Sugar Nigeria PLC, First Aluminum Nigeria PLC, GlaxoSmithKline Nigeria plc, Greif Nigeria PLC and Unilever Nigeria plc, Aluminum Extrusion PLC, Chemical and Allied Product, Dangote Cement and Dangote Sugar, First Aluminum Nigeria PLC and Flour Mills of Nigeria PLC, Greif Nigeria PLC, Paints and Coating Man and Unilever are efficient Nigeria in 2015 in that they generated very high output from a given level of input. The companies that were efficient in both 2015 and 2016 are chemical and allied products, Dangote Sugar PLC, First Aluminum Extrusion Nigeria PLC, and Flour Mills of Nigeria PLC, Greif Nigeria PLC and Unilever Nigeria. This represents 30% out of the sample firms in this study. Based on this analysis, it can be adduced that manufacturing companies in Nigeria are not technically efficient. This finding may not be unconnected with the smallness of the sample size and period observed.

Table C: Summary of average efficiency and inefficiency scores of the sampled quoted manufacturing companies for the two years, 2015 – 2016

Period	Efficiency	Number of efficient firms	Number of inefficient firms	Average efficiency	Average inefficiency
2015	Scale score	9	11	45%	55%
	CRS	7	13	35%	65%
	VRTS	9	11	45%	55%
2016	Scale score	8	12	40%	60%
	CRS	9	11	45%	55%
	VRTS	11	9	55%	45%

Source: Researchers' computation, 2017

The analysis above indicates 9, 7 and 9 were scale score, constant return to scale and variable return to technically efficient in 2016 while 8, 9 and 11 companies were scale score, constant return to scale and variable return to scale technically efficient in 2015. While others on the average where scale, constant return to scale and variable return to scale technically inefficient both in 2015 and 2016 respectively.

Table D: Input and output slacks of the sampled manufacturing firm based on 2016 CRS DEA model result

DMU	DMU names	Inputs slacks				Output slacks			
		Total assets	Fixed assets	Operating expenses	Equity	Revenue	Gross profit	Profit after tax	Profit before tax
1	7Up Nigeria	0.0000	0.0000	0.0000	0.0000	0.0000	12,4069	3588966	6196727
2	Aluminum Extrusion Indus	0.0000	0.0000	0.0000	0.0000	0.0000	760641	105107	133156
3	Ashaka Cement	7582158	0.0000	0.0000	1160000	1075026	0.0000	0.0000	895258
4	B.O.C Gases Nig	0.0000	0.0000	0.0000	185850	0.0000	0.0000	316311	442922
5	Berger Paints Nig	0.0000	0.0000	0.0000	315585	0.0000	0.0000	274901	444146
6	Beta Glass Company	20600000	0.0000	0.0000	27700000	247000000	63000000	0.0000	0.0000
7	Cement Comy of Northern Nig	0.0000	0.0000	0.0000	853746	0.0000	0.0000	334517	564767
8	Champion Breweries	0.0000	0.0000	0.0000	2388519	2861808	0.0000	0.0000	599848
9	Chemical & Allied Product	0.0000	0.0000	0.0000	18600000	0.0000	0.0000	46600000	0.0000
10	Cutix	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	Dangote Cement	0.0000	0.0000	0.0000	1450000	55900000	0.0000	0.0000	79100000
12	Dangote sugar	46900000	0.0000	0.0000	42100000	0.0000	0.0000	91800000	0.0000
13	Fidson Healthcare	877285	0.0000	0.0000	12648	1912447	0.0000	1678888	2404909
14	First AlumminiumNig	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15	Flour Mills of Nigeria	0.0000	0.0000	0.0000	0.0000	0.0000	3030000	0.0000	1680000
16	GlaxosmithklineNig	1330000	0.0000	0.0000	1030000	5244009	0.0000	1993528	0.0000
17	Grief Nig	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
18	Paint & Coatings Man	0.0000	0.0000	0.0000	543263	0.0000	576243	649096	921061
19	Unilever Nig	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
20	Union Diagnostic & Clinical Sev.	0.0000	0.0000	0.0000	1265853	1476847	0.0000	58692	994339

Table E: Input and output slacks of the sampled manufacturing firm based on 2015 CRS DEA model result

DMU	DMU names	Inputs slacks				Output slacks			
		Total assets	Fixed assets	Operating expenses	Equity	Revenue	Gross profit	Profit after tax	Profit before tax
1	7Up Nigeria	0.0000	0.0000	0.0000	0.0000	0.0000	0.00000	0.00000	0.00000
2	Aluminum Extrusion Indus	445071	0.0000	0.0000	248399	0.0000	165822	209949	283322
3	Ashaka Cement	7316855	0.0000	0.0000	1190000	2028842	78722	0.0000	880938
4	B.O.C Gases Nig	0.0000	0.0000	0.0000	223427	0.0000	229237	347360	484188
5	Berger Paints Nig	0.0000	0.0000	0.0000	315585	0.0000	750034	330317	522932
6	Beta Glass Company	20600000	0.0000	0.0000	27700000	0.0000	247000000	763000000	0.0000
7	Cement Comy of Northern Nig	0.0000	0.0000	0.0000	2168903	211895	0.0000	527950	550883
8	Champion Breweries	2460708	0.0000	0.0000	3843772	1280620	0.0000	648729	147145
9	Chemical & Allied Product	0.0000	0.0000	0.0000	18600000	0.0000	0.0000	46600000	0.0000
10	Cutix	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	Dangote Cement	0.0000	0.0000	0.0000	1450000	55900000	0.0000	0.0000	79100000
12	Dangote sugar	46900000	0.0000	0.0000	42100000	0.0000	0.0000	91800000	0.0000
13	Fidson Healthcare	0.0000	0.0000	0.0000	1873716	0.0000	0.0000	928938	849053
14	First AlumminiumNig	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15	Flour Mills of Nigeria	0.0000	0.0000	0.0000	0.0000	0.0000	3030000	0.0000	1680000
16	GlaxosmithklineNig	1330000	0.0000	0.0000	1030000	5244009	0.0000	1993528	0.0000
17	Grief Nig	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
18	Paint & Coatings Man	0.000000	0.00000	0.00000	604181	320591	740145	734915	1043906
19	Unilever Nig	0.0000	0.00000	0.0000	0.00000	0.000000	0.00000	0.000000	0.000000
20	Union Diagnostic & Clinical Sev.	1611670	0.0000	0.0000	2292019	258837	0.00000	771379	193345

The input and output slacks of tables D and E above under the constant return to scale (CRS) data envelopment analysis (DEA) model shows that four (4) of the firms used input like total assets to generate better outputs (revenues, profit before tax and profit tax) in 2016. These companies are Ashaka Cement PLC, Dangote Sugar PLC, Fidson Healthcare Nig. PLC and Flour Mills of Nigeria Plc. In the same vein, only twelve (12) of the firms used input variables such as equity to generate higher output (revenues, profit after tax and profit before tax) in 2016. These companies include Ashaka Cement PLC, BOC Gases Nig. PLC, Berger Paints Nigeria PLC, Cement Company of Northern Nigeria, Dangote Cement PLC, Fidson Healthcare Nigeria PLC, Glaxosmithkline, Paints & Coatings Nigeria Plc and Union Diagnostic and Clinical Nigeria PLC in 2015 under the constant return to scale (CRS) model shows that six manufacturing companies used the inputs to efficiently produce outputs profit before tax, revenue and profit after tax and these include Aluminum Extrusion PLC, Ashaka Cement PLC, Beta Glass Company, Champion Breweries, Dangote Sugar and Union Diagnostic & Clinical Nigeria PLC. Twelve of the companies used input variable slacks to produce better revenue, profit before tax and profit after tax. These companies are Aluminium Extrusion PLC, Ashaka Cement PLC, BOC Glasses Nigeria Plc, Berger Paints Nigeria PLC., Beta Glass Company, Cement Company of Northern Nigeria, Champion Breweries Nigeria Plc, Chemical and Allied product Nigeria Plc., Dangote Sugar Nigeria Plc, Fidson Healthcare Nigeria PLC, Paints & Coatings Nigeria PLC, and Union Diagnostic and Clinical Nigeria PLC. on the overall, only two of the sampled manufacturing firms under the input and output slacks generated better outputs from the inputs. These firms include Ashaka Cement Nigeria PLC and Dangote Sugar Nigeria PLC.

Table F: Input and output slacks of the sampled manufacturing firm based on 2016 VRS DEA model result

DMU	DMU names	Inputs slacks				Output slacks			
		Total assets	Fixed assets	Operating expenses	Equity	Revenue	Gross profit	Profit after tax	Profit before tax
1	7Up Nigeria	0.0000	0.0000	0.0000	0.0000	0.0000	5117641	8667176	14400000
2	Aluminum Extrusion Indus	0.00000	0.00000	0.00000	0.00000	0.00000	760641	105107	133156
3	Ashaka Cement	9939916	0.0000	0.00000	1170000	0.00000	0.00000	430203	681434
4	B.O.C Gases Nig	0.00000	0.00000	0.00000	201862	138653	0.00000	323867	577180
5	Berger Paints Nig	0.00000	0.00000	0.00000	319410	283271	0.0000	347910	431209
6	Beta Glass Company	2634875	0.00000	0.00000	3060501	225352	317096	162977	0.00000
7	Cement Comy of Northern Nig	0.00000	0.00000	0.00000	488033	0.00000	0.00000	813706	1387561
8	Champion Breweries	0.00000	0.00000	0.00000	482155	958043	0.00000	813706	1307561
9	Chemical & Allied Product	3260000	0.0000	0.000000	0.000000	0.00000	0.00000	0.000000	0.000000
10	Cutix	289607	0.000000	0.000000	0.000000	0.00000	0.00000	0.00000	0.00000
11	Dangote Cement	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12	Dangote sugar	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
13	FidsonHealthcare	2235997	0.00000	0.00000	0.00000	129093	0.000000	1479520	2224992
14	First AlumminiumNig	0.000000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.000000
15	Flour Mills of Nigeria	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
16	GlaxosmithklineNig	293687	0.000000	0.000000	0.000000	0.000000	2675386	5178526	7833902
17	Grief Nig	463000000	0.00000	0.000000	0.000000	0.000000	312000000	1020000000	0.0000000
18	Paint & Coatings Man	271470	0.00000	0.00000	875484	1141498	1223076	917533	1405730
19	Unilever Nig	0.00000	0.00000	0.00000	0.00000	40500000	0.00000	0.000000	0.0000000
20	Union Diagnostic & Clinical Sev.	0.000000	0.000000	0.000000	721074	143978	0.000000	184228	193673

Table G: Input and output slacks of the sampled manufacturing firm based on 2015 VRS DEA model result

DMU	DMU names	Inputs slacks				Output slacks			
		Total assets	Fixed assets	Operating expenses	Equity	Revenue	Gross profit	Profit after tax	Profit before tax
1	7Up Nigeria	0.000000	0.00000	0.0000000	0.000000	0.00000	0.00000	0.000000	0.00000
2	Aluminum Extrusion Indus	0.000000	0.000000	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000
3	Ashaka Cement	7789425	0.00000	0.000000	107000000	6439941	0.00000	290541	982973
4	B.O.C Gases Nig	104178	0.00000	0.00000	266799	0.00000	0.00000	319214	517738
5	Berger Paints Nig	757219	0.00000	0.000000	365687	916901	0.00000	345758	431037
6	Beta Glass Company	3007002	0.00000	0.000000	3288446	394712	325931	161860	0.000000
7	Cement Comy of Northern Nig	0.000000	0.00000	0.000000	597893	0.00000	0.000000	796083	1344240
8	Champion Breweries	0.0000000	0.000000	0.0000000	502929	500119	0.000000	462889	522971
9	Chemical & Allied Product	3260000000	0.00000	0.00000	0.000000	0.000000	0.000000	0.000000	0.0000000
10	Cutix	199351	0.000000	0.000000	0.00000	0.00000	168509	218844	329308
11	Dangote Cement	0.000000	0.00000	0.000000	0.00000	0.000000	0.000000	0.000000	0.000000
12	Dangote sugar	0.00000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.000000
13	Fidson Healthcare	2105389	0.000000	0.00000	0.00000	1028510	0.00000	1180902	1669384
14	First AlumminiumNig	0.00000	0.00000	0.00000	0.00000	0.00000	0.000000	0.000000	0.0000000
15	Flour Mills of Nigeria	0.000000	0.000000	0.00000	0.00000	0.00000	0.000000	0.000000	0.00000
16	GlaxosmithklineNig	21426172	0.000000	0.000000	7538102	0.000000	952424	599995	1997002
17	Grief Nig	4630000000	0.00000	0.00000	0.000000	0.00000	31200000000	1020000000	0.000000
18	Paint & Coatings Man	210565	0.00000	0.00000	679069	192145	740391	683512	1059988
19	Unilever Nig	0.00000	0.00000	0.00000	0.00000	4050000000	0.000000	0.000000	0.000000000
20	Union Diagnostic & Clinical Sev.	0.0000000	0.000000	0.0000000	775076	932568	0.0000000	152823	241283

The input and output slacks under the variable return to scale (CRS) in the above F table indicate that in 2016, eight (8) of the firms generated higher outputs, profit after tax and profit before tax while eight (8) also generated better outputs, profit before tax and profit after tax from the inputs, total assets and equity, they were not able to generate better income with the input variables in the year 2016. In 2015 in the input and output slacks table above G, ten of the firms generated better outputs with the total assets while only nine (9) had better income from the employment of equity under the variable return to scale (VRS).

CONCLUSION AND RECOMMENDATION

This study has robustly examined the technical efficiency of quoted manufacturing companies in Nigeria using data envelopment analysis (DEA) approach. Efficiency analysis of firms is one of the primary concerns of stakeholders in the light of the present day economic challenges like in Nigeria. Only those firms who are efficient in resources utilization and occupied the production frontier curve can survive the challenges in the corporate world. The analysis about the technical efficiency of the manufacturing firms under constant return to scale (CRS), variable return to scale (VRTs) and scale efficiency score points out that the sampled firms technically operated below average in the period observed. The conclusion made here is that the finding may not be unconnected with the smallness of the sample size and period. It is therefore recommended that manufacturing companies need to scale down cost to maximum better output (profit) with a view to satisfying the wealth maximization goal. Future researchers are encouraged to constantly examine the efficiency of manufacturing firms using an increased sampled size, period, more input and output variables like staff cost, goodwill, current asset, return on capital employed, and earnings per share, amongst others. The result obtained from the use of these variables would assist corporate managers understand and adopt a better approach to increasing the efficiency of firms. It is also suggested in this study that more efficiency analysis be carried out using other efficiency analysis technique like the stochastic frontier analysis for quoted manufacturing companies for empirical results comparison. Future researchers should compare the efficiency of quoted manufacturing firms in Nigeria with others in the sub-Saharan Africa using data envelopment analysis approach for meaningful comparison. Further researches should be carried out by future researchers to ascertain the determinants of manufacturing firms' efficiency in Nigeria and the extent those factors / determinants really influence the efficiency using panel data or cross – sectional regression methods, correlation analysis and other effective estimation techniques.

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