Efficiency Measurement in Selected Manufacturing Firms in Nigeria: Further Evidence from Data Envelopment Approach

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Abstract
This study assesses the technical efficiency of some of the selected firms in the Nigerian manufacturing sector, using multi-stage based variable returns to scale (VRS) Data Envelopment (DE) approach. The study found that between 2008 and 2017, the number of efficient firms on annual basis ranged from 60 per cent to 90 per cent. The result of the technical efficiency ranking further revealed that Dangote Sugar was the most technically efficient firm, while B.O.C Gases was the second most technically efficient firm between 2008 and 2017. Also, Cadbury, Cement Company of Northern Nigeria and African Paints emerged third, fourth and fifth most technically efficient manufacturing firms respectively, while A. G. Leventis was the least technically efficient firm during the period of analysis. The study recommended that the inefficient firms should carefully adopt an optimal input mix, to cut cost and improve outputs. The discussion on the Peers and Lambdas of the output-based orientation can serve as a reference model to the inefficient firms desiring to achieve efficiency.

Keywords: Data Envelopment Analysis, Efficiency, Manufacturing sector, Nigeria
JEL Classification: C67, L6, L25

I. Introduction

Most industries across the world depend heavily on the efficiency of their manufacturing operations to generate quality outputs that customers can pay for. An increasing inefficiency in the manufacturing process triggers higher production cost. Johnson (2019) noted that, the problem of inefficiency often degenerates from wrecked machines, low morale of employees, as well as a dysfunctional industrial structure. The consequence of such upsurge in production cost is higher product prices and possible shrinkage in the sales volume of the firm. To mitigate the menace of manufacturing inefficiency, it therefore becomes germane for firms to enhance their manufacturing processes efficiency. Generally, manufacturing inefficiency could be attributed to mismanagement of human and non-human resources as well as capacity under-utilisation (Ioanna, Angelos & Evangelia, 2011).

A firm can be considered efficient if that firm can employ the same amount of inputs to produce higher level of outputs compared to other firms (Akbar,

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2010). Kurniasari, (2011) further noted that, a firm is said to be efficient if it can employ less inputs in relation to the inputs utilised by other firms in the production of the same amount of output. Efficiency is a vital feature of a well organised manufacturing sector and it can be seen as the relationship between the volume of output generated and the amount of inputs utilised in the course of production. In a nutshell, it is measured as the ratio of output in relation to the amount of inputs employed in a production process (Muhammad, Eva & Hizir, 2018).

Several attempts have been made through the formulation of various industrial policies and a number of economic reforms by Nigerian policy makers to stimulate economic activities through the development of the manufacturing sector, strengthen the structure of the economy and further strike a balance between manufacturing and other allied sectors (Adugna, 2014). This is imperative as the Nigerian manufacturing sector has exerted enormous bearings on the nation's economy particularly in the area of income generation, reduction in the rate of unemployment, raising the exports base, stimulating productivity and enhancing global competitiveness.

An efficient manufacturing sector promotes a good value chain system through procurement, production, quality control, distribution and marketing (Kravitt, 2019). It also attracts more local and foreign investments, and enhances the growth of the entire economy. In addressing efficiency related issues across different sectors, several studies have been conducted with particular interest in North American, Middle East, European, Asian and a few African markets. For instance, Al-Shammari (1999) focused on the operational efficiency of manufacturing shareholding companies in Jordan, while Zhu (2000) employed a multi-factor performance model among the Fortune 500 companies. Renuka and Kalirajan (2000) also examined efficiency of the manufacturing sector of Singapore; Mostafa (2007) evaluated market efficiency in Egypt, while Baten, Kamil and Fatama (2009) examined the technical efficiency among manufacturing companies in Bangladesh. Similarly, Tahir and Yusot (2011) assessed the technical and scale efficiency of public listed firms in Malaysia, while Haran and Chellakumar (2012) studied the technical efficiency of Kenyan manufacturing sector. In addition, Jamali, Mirza and Anka (2014) examined industrial efficiency in the Pakistani textile industry, Ömer and Emr (2014) analysed manufacturing efficiency among Turkish firms, while Muhammad et al. (2018) evaluated the efficiency of Manufacturing Sector in Indonesia. Yet, very little has been established in the context of the Nigeria manufacturing sector, notwithstanding the country's growing economic stance.

Furthermore, ownership concentration (such as Government Ownership, Block Ownership Concentration, and Institutional Ownership), firm size and Firm Listing Age tend to affect the efficiency of a firm. For instance, government owned enterprises are often characterized by inefficiency due to poor risk management, frequent government intrusion and corruption (OECD, 2017). Also, a firm performance tends to improve with the age due to long term experience (Ilaboya & Ohiokha, 2016). However, the few notable efficiency studies in Nigeria such as Osamwonyi and Imafidon (2016) and Fapohunda, Ogbeide and Igbinigie (2017) both adopted input mix such as total asset, shareholder's equity and operating expenses without considering the relevance of ownership concentration and Firm listing Age, which can affect the efficiency of such firms. Thus, this is the motivation for this study. Arising from the foregoing, the aim of this study is to empirically test the technical efficiency of the Nigerian manufacturing Firms, using Data Envelopment (DE) approach.

Following this introduction, section 2 presents the theoretical and empirical review of relevant literatures, while section 3 discusses the methodology. Section 4 presents the empirical findings and their policy implications, while section 5 concludes.

II. Literature Review

II.1 Theoretical Issues

Palmer and Torgerson (1999) defined efficiency as the relationship between the observed ratio of outputs to inputs of a unit, compared to an optimal ratio. The optimal ratio is defined by the highest level of output that could be produced given the same quantity of inputs. It can also be defined as the ability to combine least inputs to produce the same level of output (Khumbakar, Ghosh & McGuckin, 1991). Efficiency has remained a complex issue to solve in the course of production because, in Nigeria, like in every other economy, there are a number of issues that necessitate significant attention in order to boost efficiency in the system.

For instance, insufficient capital in the course of development poses a major challenge to the system and this has to be addressed since poor financing has the tendency of crippling efficiency in the production process. Increasing productivity necessitates more capital. In addition, the government has the responsibility of increasing the scope of infrastructural expansion. The idea of technical efficiency borders on the expansion of output using a specific set of productive inputs. A firm is said to be inefficient when there are variations between the realised output and the maximum attainable output level (Laura, Patrick, Joris, Bethuel & Peter, 2019).

The most commonly applied technique for measuring technical efficiency is the Ratio Analysis. This method is utilised by way of establishing the mathematical relationship between inputs and outputs, by taking the ratio of outputs in relation to the corresponding inputs at a point in time. The deficiency associated with this method arises when there is an instance of multiple inputs and outputs relating to the firms in question which makes it difficult to determine the relative efficiency of these firms by merely computing the firms' inputs-outputs ratios. Consequently, a number of robust interrelated quotients are considered in establishing efficiency among a pool of decision-making units (Omer & Emr, 2014).

Ouattara (2012) noted that efficiency of a firm or sector can be examined using both parametric and nonparametric methods. According to Nuama (2006), the parametric method is used to estimate a function with fixed set of parameters such as Cobb-Douglass, CES, Translog. Such function can be estimated with the aid of both econometric and non-econometric techniques such as the least squares method or the maximum likelihood procedure. Murillo-Zamorano (2004) explained that the nonparametric frontier doesn't follow a fixed set of parameters. The non-parametric approach is used to differentiate between the convex and non-convex functions. Free Disposal Hull (FDH) and Data Envelopment (DE) are utilised in estimating the non-parametric production frontier. The nonparametric frontiers can be analysed using the mathematical programming methods (Leleu, 2006).

According to Kumbakar and Lovell (2000), if the variations between the realised and the expected level of outputs can only be described by the inefficiency of the manufacturer, the frontier is said to be deterministic. But if the variations can be explained by both the inefficiency of the manufacturer as well as the manifestation of some random variables which are beyond the control of the firm, such frontier is said to be stochastic. In the submission of Ray (2008), the stochastic frontier model that relates to firms in an industry that produces output vectors (y) by utilising input vectors (x) can be demonstrated with the aid of the production possibility bundle (T).

Also, an input-output combination (x, y) is well-thought-out to be feasible, strictly on the condition that (x, y) are elements of (T).However, the input-oriented technical efficiency of an optimal input-output combination (x, y) is measured by varying various inputs to yield the certain output level. Correspondingly, the output-oriented technical efficiency of the same set can be measured by using same inputs combinations to achieve different outputs level. Generally, the efficiency theory has been extensively espoused in various experimental explorations, and a number of recent studies on efficiency measurement have adopted non-parametric techniques with the aid of mathematical programming (Tung, Lin & Wang, 2010; Jiankang, 2014; Tao, Liu, & Chen, 2013; Tsolas & Charles, 2015; Lozano, 2015; Osamwonyi & Imafidon, 2015; Osamwonyi & Imafidon, 2016; Cesaroni, 2017; Fapohunda, Ogbeide & Igbinigie, 2017; Muhammad et al., 2018).

II.2 Empirical Literature

A number of empirical studies have been conducted in evaluating issues relating to technical efficiency among manufacturing firms across the globe. However, to the best knowledge of the authors, very limited studies have addressed the subject matter in the context of Nigeria. For instance, Baten et al. (2009) examined the technical efficiency among manufacturing companies in Bangladesh using stochastic frontier analysis by means of Cobb-Douglas production function and established that about 55 per cent of the firm's output level was half normal distribution. Tahir and Yusof (2011) utilised inputs-oriented DEA method to assess the technical and scale efficiency of fourteen public listed firms in Malaysia and found that only one firm was technically efficient during the estimation period. Haran and Chellakumar (2012) studied the technical efficiency of Kenyan manufacturing sector by employing Pearson correlation and inputs-oriented data envelopment analysis techniques. They established that, higher level of efficiency was associated with medium size and large-scale firms, while small-scale firms were inefficient between 2009 and 2011.

Similarly, Jamali et al. (2014) examined industrial efficiency in the Pakistani textile industry and established that, large scale manufacturing rate deteriorated due to industrial structural reforms in the sixties, while in 2002/03, minimal progress was established in the manufacturing sector. Ömer and Emr (2014) also analysed manufacturing efficiency among Turkish firms in the period 1996-2008 with the aid of DE and found that, the most efficient firms included those producing Food, Coke, Drinks, Leather and Leather Products, Non-Metallic, other Metal Products, Nuclear Fuel, Refined Petroleum Products, Tobacco Products and Wood Products, while the least efficient ones consisted of Textile Producing firms. Muhammad et al. (2018) evaluated the efficiency of Manufacturing Sector in Indonesia and found that the most efficient manufacturers comprised those in the Rubber, Chemical, Fertilizer industries, while Foods and Tobacco producing companies were the least efficient.

Prominent among the few empirical studies conducted in Nigeria include Osamwonyi and Imafidon (2015), who carried out a survey on the allocative efficiency of listed manufacturing firms in Nigeria, using multi-stage output oriented variable returns to scale DEA approach with cost of goods sold, operating expenses, shareholders' equity and total assets as input variables, while the output series comprised net profit, return on asset, return on equity and sales. They however established inefficient allocation of resources with evidence of more slacks for the input series with cost of goods sold (47 per cent), operating expenses (71 per cent), shareholders' equity (77 per cent) and total asset (114 per cent) in the production process.

Osamwonyi and Imafidon (2016) further studied the technical efficiency among manufacturing firms listed on the Nigerian Stock Exchange employing output-oriented data DEA model. The study showed that the sampled manufacturing firms were efficient with a variable return to scale mean score of 85 per cent as well as scale efficiency average score of 76 per cent. In similar fashion, Fapohunda et al. (2017) assessed the technical efficiency among twenty sampled manufacturing firms in Nigeria by employing input and output-oriented DE model and found that, only 35 per cent of the listed manufacturing companies in Nigeria were technically efficient, while 65 per cent suffered technical inefficiency from 2015 to 2016.

III. Methodology

III.1 Basic Theory of Data Enveloping (DE)

DE is a technique employed in the estimation of efficiency of the various decision-making units (DMUs) conditioned upon a set of inputs and outputs. It is adopted for the measurement of the strength of weighted input and output ratios in relation to the efficiency of other decision-making units (Charnes, Cooper & Rhodes, 1978). By employing DEA technique, a number of DMUs are evaluated, with individual DMU taking m set of inputs to maximise outputs level. Nevertheless, the restriction associated with this optimisation is that, the efficiency score of any economic unit among the sampled decision-making units must not exceed 1 and the functions ought to capture all features such as the weights of all inputs and outputs which ought to exceed zero. A model of such nature is presented as a linear fraction programming relation as follows:

Maximise $\frac{\sum_i u_i y_{iq}}{\sum_j v_j x_{jq}}$

Subject to $\frac{\sum_i u_i y_{ik}}{\sum_j v_j x_{jk}} \leq 1 \; k = 1, 2, 3, \dots \dots, n \dots \dots \dots$ (1)

$u_i \geq \in \quad i = 1,\; 2, 3, \dots \dots, sv_j \leq \in \quad j = 1, 2, 3, \dots \dots, m$

The transformed linear form of Equation (1) above can be expressed in a matrix format as follows;

Maximise $z = u^T Y_q$ (2)

Subject to $v^T X_q = 1$ (2.1)

$u^T Y - v^T X \leq 0, u_i \geq \in, v_j \leq \in$

Model (1) above is frequently referred to as the primary CCR DEA model advanced by Charnes et al. (1978). The dual form of this model is established as follows:

Minimise $f = \theta - \epsilon(e^T S^+ + e^T S^-)$ (3)

Subject to $Y\lambda i - S^+ = Yq$ (3.1)

$X\lambda i + S^- = \theta Xq$ (3.2)

$\lambda_i, S^+, S^- \geq 0$

Where $\lambda_i = (\lambda_1, \lambda_2, \lambda_3, \lambda_4 \dots\dots, \lambda_n)$, $\lambda_i \geq 0$ is a vector that relates to specific decision making unit, s^+ and s^-account for the vectors of extra input and output variables, eT= (1, 1, .., 1) and ∈ is a fixed term that must exceed zero, and is generally projected at 10^{-6} or 10^{-8}. In calculating the efficiency of unit DMUq, model (3) tries to find a virtual unit linked to inputs Xλ and outputs Yλ, which are a linear fusion of inputs and outputs of other DMUs and are better than the inputs and outputs combination of DMUq under investigation. In the event that the inputs of the virtual unit Xλ ≤Xq and outputs Yλ ≥ Yq, DMUq is considered efficient.

In the instance that no virtual DMU with entreated qualities subsists or if the virtual DMU is indistinguishable with the DMU under assessment, then, Xλ= Xq and Yλ= Yq. Also, if any DMU is CCR efficient, then, the value of θ as well as all additional variables s^+ and s^-equals zero. The optimal score of the main function f* indicates the efficiency score of the particular DMU being evaluated. A lower score suggests low efficiency. When θ is less than one, the DMU is inefficient. Models (1) and (3) are input-oriented. However, the output-oriented versions are presented as follows:

Maximise $g = \Phi + \epsilon(e^T S^+ + e^T S^-)$ (4)

Subject to $Y\lambda i - S^+ = \Phi Y q$ (4.1)

$X\lambda i + S^- = Xq$ (4.2)

$\lambda_i, S^+, S^- \geq 0$

From the above representations, θ represents the efficiency score in the input-oriented model, while Φ indicates the rate of efficiency in the output-oriented model. From equation (4) above, DMUq is CCR efficient in the event that the optimal value of g* = 1. If the value g*exceeds 1, then, DMUq is CCR inefficient. Φ suggests the necessity for output improvement to attain efficiency. In computing the optimum solution for the CCR function, the efficiency scores generated from the objective functions should be inverted, such that; f* = 1/g*. Equations (1), (3) and (4) follow constant returns to scale. In addressing issues relating to variable returns to scale, equations (3) and (4) need to be modified slightly with the inclusion of eTλ = 1 (convexity condition). Subsequently, the resulting models are now regarded as BCC (Banker, Charnes, Cooper) models. When more input and output variables s– and s+ are added to the models, the resulting equations take the following forms;

Input-oriented CCR model:

$X'q = \theta Xq - s - Y'q = Yq + s+$ (5)

Output-oriented CCR model:

$X'q = Xq - s - Y'q = \Phi Yq + s+$ (6)

III.2 Method of Data Collection

The study utilised secondary data sourced from Nigerian Stock Exchange Factbook, Annual reports and financial statements of the selected companies for the period 2008 to 2017. 10 out of a total population of 16 quoted manufacturing firms in 2019 (63 per cent) were taken as sample size due to data unavailability, and the selected firms include 7Up Nigeria, A. G. Leventis, Dangote Sugar, African Paints, Aluminium, B.O.C Gases, Berger Paints, Beta Glass Company, Cadbury Nigeria and Cement Company of Northern Nigeria. The input variables of the companies comprise Government Ownership, Block Ownership, Institutional Ownership, Total Assets and Firm Listing Age, while the output variables include Return on Asset and Tobin's Q. The choice of these variables is informed by the need to measure how best a firm can combine ownership concentration with its Listing Age and Total Assets to achieve improved performance.

Villalonga and Amit (2006) argue that there is a direct link between ownership concentration and corporate business performance because the board of directors elected by the owners' acts as the intermediary between them and their agents, as the board is charged with four main responsibilities: leadership; stewardship; monitoring; and reporting back to the owners, which has a direct bearing on financial performance. Essentially, Levraum & Van den Berghe (2007) argues that ownership concentration is the primarily driving factor both to investors and creditors because owners of a firm have economic relations with the firm and influences the types of decisions taken by a firm to decrease the level of financial risk and improve its performance. This is because ownership concentration has the capacity to put good governance mechanisms structures in place that can boost company's capacity to attract outside capital (Le & Chizema, 2011).

The study adopted non-parametric output orientated DEA with variable returns to scale (VRS) assumptions, using multi-stage DEA procedure. The technique has numerous advantages. For instance, it is flexible to use and doesn't require stringent conditions compared to parametric methods which must fulfil a set of underlying assumptions in predicting mathematical relationships. These qualities make DEA exceptional and more reliable compared to parametric techniques (Ji & Lee, n.d.). Similarly, DEA possesses a suitable mathematical arrangement for performance evaluation by establishing input-outputs models which can combine infinite number of inputs and outputs for infinite DMUs. It also offers managerial tools for reports and optimisation procedures. The data were analysed with the aid of MDEAP 2Programme (Coelli, 1996).

IV. Discussion of Empirical Findings and Policy Implications

This section is devoted to the presentation and discussion of the various findings of the study as well as their implications for policy. The findings and the interpretations are on the basis of output-oriented multi-staged VRS Data Envelopment Analysis.

IV.1 Basic Efficiency Scores: Output-Oriented Multi-Staged VRS (θvrts)

Tables 1A and Table 1B report the summary results of the Output-Oriented Multi-Staged VRS Efficiency Scores for the sampled manufacturing firms (DMUs) during the period of assessments. From the results, 6 firms, representing 60 per cent of the total decision-making units were technically efficient, while 4 firms which account for the remaining 40 per cent were inefficient in 2008. The technically efficient firms, in 2008, were Dangote Sugar, African Paints, Aluminium Extrusion Industry, B.O.C Gases, Berger Paints and Cement Company of Northern Nigeria, while those that operated below efficiency level consist of 7Up Nigeria, A. G. Leventis, Beta Glass Company and Cadbury Nigeria.

The implication of the above is that, for the inefficient firms to eventually become efficient in year 1, they need to upscale their input-output performance by 54 per cent (for 7Up Nigeria), 41 per cent (in the case of A. G. Leventis), 53 per cent (in the case of Beta Glass Company) and 48 per cent (in the case of Cadbury), while the efficient ones need not change their input-output combination, since they all operated optimally. The inference that can be drawn from the above finding is that, the Nigerian manufacturing sector was 60 per cent efficient (explained by the number of firms that were technically efficient) with a Mean Efficiency Score of 0.8 in year 1 (2008).

From the results also, 60 per cent of the total number of manufacturing firms captured in the study were technically efficient, while the remaining 40 per cent were inefficient in 2009. The performance of the Nigerian manufacturing sector in 2009, though recorded a Mean Efficiency Score of 0.77, was very similar to that of 2008. In 2010, the sector witnessed an improvement in performance both in the Mean Efficiency Score as well as the number of firms that operated in the efficiency region. Explicitly, 70 per cent of the manufacturing firms in Nigeria were technically efficient with a Mean Efficiency Score of 0.83, while the remaining 30 per cent were inefficient in 2010. In addition, the sector was 80 per cent efficient with a Mean Efficiency Score of 0.89 in year 4 (2011), 70 per cent efficient with a Mean Efficiency Score of 0.87 in year 5 (2012), while 70 per cent of the manufacturing firms were technically efficient, while the remaining 30 per cent were inefficient in 2013.

Generally, it was observed that most of the companies have been increasingly efficient since 2014. For instance, the sector was 80 per cent efficient with a Mean Efficiency Score of 0.90 in year 7 (2014), 80 per cent efficient with a Mean Efficiency Score of 0.93 in year 8 (2015), 90 per cent efficient with a Mean Efficiency Score of 0.97 in year 9 (2016), while 90 per cent of the manufacturing firms were technically efficient, while the remaining 10 per cent were inefficient in 2017. This finding is consistent with finding of Osamwonyi and Imafidon (2016) who showed that the sampled manufacturing firms were efficient with a variable return to scale mean score of 85 per cent as well as scale efficiency average score of 76 per cent. The finding however contradicts finding of Fapohunda et al. (2017), who found that only 35 per cent of the listed manufacturing companies in Nigeria were technically efficient, while 65 per cent suffered technical inefficiency from 2015 to 2016 using different proxies.

Such increasing efficiency could be linked to proper selection of the ideal manufacturing process design, increasing competition in the industry, proper asset management among the manufacturing firms, improved supply chain and the direct link between ownership concentration and corporate business performance (Villalonga and Amit, 2006). Explicitly, such increasing efficiency could be driven by ownership concentration since owners of a firm have economic relations with the firm and influences the types of decisions taken by a firm to decrease the level of financial risk and improve its performance (Levrau & Van den Berghe, 2007). Interestingly, Dangote Sugar, African Paints, Aluminium Extrusion Industry, B.O.C Gases, Berger Paints, 7Up Nigeria, Beta Glass Company, Cadbury Nigeria and Cement Company of Northern Nigeria were among the technically efficient companies, while A. G. Leventis operated below efficiency level in 2016 and 2017 respectively.

In terms of how each of the manufacturing firms fared in the course of the assessments, 7Up Nigeria operated in the region of technical efficiency in 5years (2011, 2014, 2015, 2016 and 2017) out of the 10years covered, while A. G. Leventis was technically inefficient throughout the period of evaluation. Also, Beta Glass Company was efficient only in two years (2016 and 2017), while Cadbury suffered technical inefficiency only in two years (2007 and 2008). Conversely, Dangote Sugar, African Paints, Aluminium Extrusion Industry, B.O.C Gases, Berger Paints and Cement Company of Northern Nigeria were technically efficient in the period of analysis. The ten-year aggregate reported in the last column of Table 1B indicates the overall efficiency of each firm in the ten-year estimation period. It implies that, 7Up Nigeria was 50 per cent efficient (5yrs=5/10=0.5*100), while Beta Glass company was only 20 per cent efficient (2yrs=2/10=0.2*100) in the period of assessments. Firms like Dangote Sugar, African Paints, Aluminium Extrusion Industry, B.O.C Gases, Berger Paints and Cement Company of Northern Nigeria were 100 per cent efficient (10yrs=10/10=1*100) throughout the 10-year survey. The results are however reported in Table 1, Figure 1 and 2 respectively.

Table 1A: Efficiency Scores Summary: Output-Oriented Multi-Staged VRS (θvrts)

DMUs	2008	2009	2010	2011	2012	2013
7Up Nigeria	0.46	0.46	0.45	1.00*	0.91	0.51
A. G. Leventis	0.59	0.41	0.28	0.29	0.24	0.30
Dangote Sugar	1.00*	1.00*	1.00*	1.00*	1.00*	1.00*
African Paints	1.00*	1.00*	1.00*	1.00*	1.00*	1.00*
Aluminium	1.00*	1.00*	1.00*	1.00*	1.00*	1.00*
B.O.C Gases	1.00*	1.00*	1.00*	1.00*	1.00*	1.00*
Berger Paints	1.00*	1.00*	1.00*	1.00*	1.00*	1.00*
Beta Glass Company	0.47	0.57	0.55	0.58	0.51	0.48
Cadbury Nigeria	0.52	0.29	1.00*	1.00*	1.00*	1.00*
Cement Company of Northern Nigeria	1.00*	1.00*	1.00*	1.00*	1.00*	1.00*
Mean Efficiency Scores	**0.80**	**0.77**	**0.83**	**0.89**	**0.87**	**0.83**
Annual Rating	**60%**	**60%**	**70%**	**80%**	**70%**	**70%**

* Indicates efficient firm

Source: Authors' Computation using MDEAP2 Program

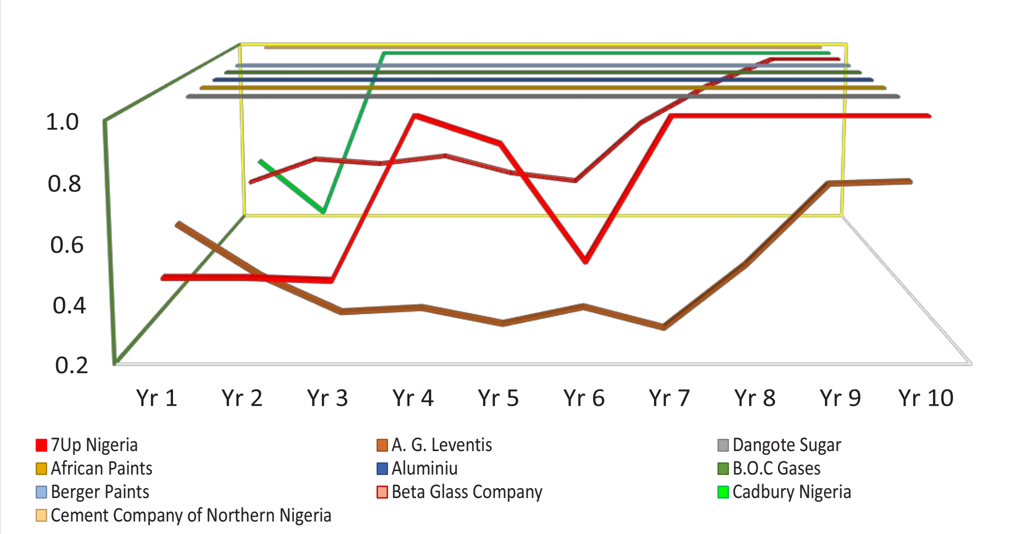
Table 1B: Efficiency Scores Summary: Output-Oriented Multi-Staged VRS (θvrts)

DMUs	2014	2015	2016	2017	Ten Yr. Rating
7Up Nigeria	1.00*	1.00*	1.00*	1.00*	50%
A. G. Leventis	0.22	0.45	0.73	0.74	0.0%
Dangote Sugar	1.00*	1.00*	1.00*	1.00*	100%
African Paints	1.00*	1.00*	1.00*	1.00*	100%
Aluminium	1.00*	1.00*	1.00*	1.00*	100%
B.O.C Gases	1.00*	1.00*	1.00*	1.00*	100%
Berger Paints	1.00*	1.00*	1.00*	1.00*	100%
Beta Glass Company	0.73	0.88	1.00*	1.00*	20%
Cadbury Nigeria	1.00*	1.00*	1.00*	1.00*	80%
Cement Company of Northern Nigeria	1.00*	1.00*	1.00*	1.00*	100%
Mean Efficiency Scores	**0.9**	**0.93**	**0.97**	**0.97**	
Annual Rating	**80%**	**80%**	**90%**	**90%**	

* Indicates efficient firm

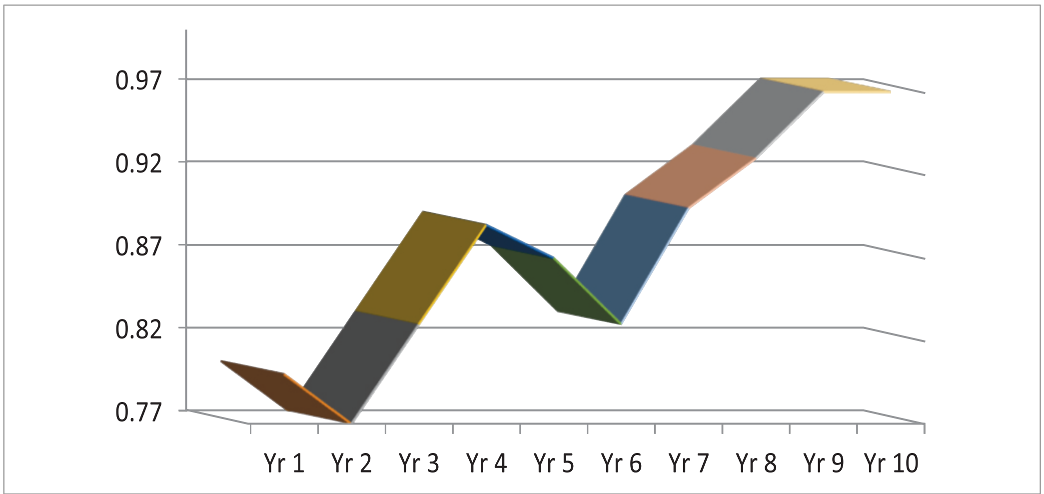
Source: Authors' Computation using MDEAP2 Program

Figure 1: Efficiency Scores in a Multi-Staged VRS (2008-2017)



Source: Authors' Computation

Figure 2: Mean Efficiency Scores (2008-2017)



Source: Authors' Computation

IV.2 Output Based Orientation: Peers and Lambda

A Peer or Reference set shows an efficient firm's inputs/output combination that must be followed by an inefficient firm as a reference for efficiency, while peer weight (Lambda) is a unit of input/output variables of the respective reference (efficient) firm that can be adopted by an inefficient one. Tables 2A and Table 2B present the Peers and Lambdas of the output-based orientation

DEA for the 10-year period. The results reveal that, inefficient firm such as 7Up Nigeria should have produced at least 25 per cent of the output combination of Dangote Sugar or 75 per cent of B.O.C Gases outputs mix to achieve efficiency in year 1 (2008). Similarly, A. G. Leventis ought to have adopted 13 per cent of the output bundle of Dangote Sugar or 87 per cent of B.O.C Gases outputs set. Beta Glass Company should have adopted 17 per cent of the output bundle of Dangote Sugar, 39 per cent of Aluminium Extrusion Industry's outputs set or 44 per cent of Cement Company of Northern Nigeria's outputs mix to become efficient in year 1. But Cadbury could only produce 100 per cent of B.O.C Gases' output mix in that same year, while the efficient ones did not have to follow any firm, since they were efficient in their performances during the period under consideration.

Furthermore, inefficient firm such as A. G. Leventis ought to have produced at least 7 per cent of the output combination of 7Up Nigeria, 50 per cent of Cadbury's outputs mix or 44 per cent of B.O.C Gases' outputs set in order to operate on the efficiency frontier in year 9 (2016). In the same way, A. G. Leventis should have produced at least 61 per cent of the output combination of Cadbury, 13 per cent of African Paints' outputs mix or 27 per cent of Berger Paints' outputs set to achieve efficiency in year 10, while the efficient ones, such as Dangote Sugar, African Paints, Aluminium Extrusion Industry, B.O.C Gases, Berger Paints, 7Up Nigeria, Beta Glass Company, Cadbury Nigeria and Cement Company of Northern Nigeria, did not have to follow any firm in 2016 and 2017, since they were efficient in their performances in those years. Tables 2A and Table 2B report the Peers and Lambdas of the output-based orientation DEA for the 10-year period.

Table 2A: Peers and Lambdas of the output - based orientation DEA (2008 - 2013)

2008 Peers and Lambdas	**Dangote Sugar**	**African Paints**	**Aluminium Extrusion Industry**	**B.O.C Gases**	**Cement Company of Northern Nigeria**
7Up Nigeria	0.25			0.75	
A. G. Leventis	0.13			0.87	
Beta Glass Company	0.17		0.39		0.44
Cadbury Nigeria				1.00	

2009 Peers and Lambdas	Dangote Sugar	B.O.C Gases	Cement Company of Northern Nigeria	Berger Paints	Aluminium Extrusion Industry
7Up Nigeria	0.25	0.75			
A. G. Leventis			1.00		
Beta Glass Company			1.00		
Cadbury Nigeria		1.00			

2010 Peers and Lambdas	Dangote Sugar	African Paints	B.O.C Gases	Cadbury Nigeria	Cement Company of Northern Nigeria
7Up Nigeria	0.37		0.28	0.35	
A. G. Leventis	0.30	0.25	0.45		
Beta Glass Company	0.23		0.73		0.05

2011 Peers and Lambdas	7Up Nigeria	Dangote Sugar	African Paints	Cement Company of Northern Nigeria	B.O.C Gases
A. G. Leventis			0.33		0.67
Beta Glass Company				0.58	0.42

2012 Peers and Lambdas	Dangote Sugar	African Paints	Aluminium Extrusion Industry	B.O.C Gases	Berger Paints	Cadbury Nigeria
7Up Nigeria	0.34				0.28	0.38
A. G. Leventis		0.67				0.33
Beta Glass Company	0.23	0.03		0.70		0.03

2013 Peers and Lambdas	Dangote Sugar	Cement Company of Northern Nigeria	Aluminium Extrusion Industry	B.O.C Gases	Berger Paints	Cadbury Nigeria
7Up Nigeria	0.33				0.13	0.54
A. G. Leventis		0.02		0.55		0.43
Beta Glass Company	0.01	0.58				0.42

Source: Authors' Computation using MDEAP2 Program

Table 2B: Peers and Lambdas of the output-based orientation DEA (2014-2017)

2014 Peers and Lambdas	**Cadbury Nigeria**	**Dangote Sugar**	**African Paints**	**Cement Company of Northern Nigeria**	**B.O.C Gases**	
A. G. Leventis	0.81		0.09		0.10	
Beta Glass Company		0.15		0.86		
2015 Peers and Lambdas	7Up Nigeria	Dangote Sugar	Cement Company of Northern Nigeria	Aluminium Extrusion Industry	B.O.C Gases	Berger Paints
A. G. Leventis	0.29				0.10	0.61
Beta Glass Company	0.27		0.44	0.02		0.26
2016 Peers and Lambdas	7Up Nigeria	Dangote Sugar	Cadbury Nigeria	Aluminium Extrusion Industry	B.O.C Gases	
A. G. Leventis	0.07		0.50		0.44	
2017 Peers and Lambdas	Cadbury Nigeria	Dangote Sugar	African Paints	Berger Paints	B.O.C Gases	
A. G. Leventis	0.61		0.13	0.27		

Source: Authors' Computation using MDEAP2 Program

In a similar vein, the summary of peers and references as well as the DMUs efficiency ranking are presented in Table 3. Specifically, the firms were ranked using two criteria. The first criterion was the total number of years each firm operated on an efficiency level, while the second condition borders on the number of times each firm was used as a peer/reference for efficiency. These two criteria were both necessary and sufficient conditions, owing to the fact that a firm can be efficient but only used once as a peer/reference for efficiency, while another efficient firm can be used as a peer/reference for efficiency as many times as the number of inefficient firms in that particular period. For instance, Cadbury Nigeria and Berger Paints were both technically efficient in 2013. However, Berger Paints was used once, while Cadbury was used 3times as a peer/reference for efficiency in that same year.

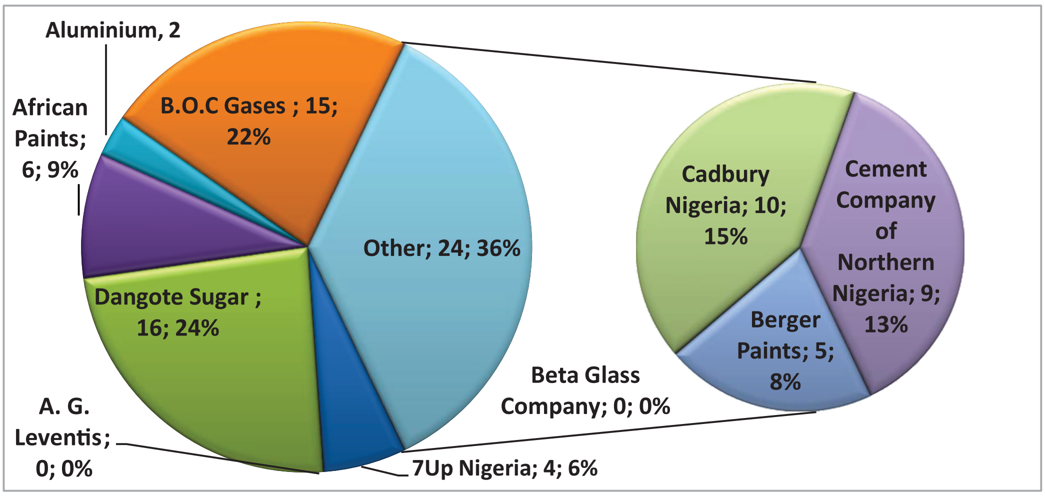
Explicitly, the result indicates that 7Up Nigeria was used 4 times, A. G. Leventis was never used, Dangote Sugar (16 times), African Paints (6 times), Aluminium Extrusion Industry (twice), while B.O.C Gases was used 15 times as a peer/reference for efficiency respectively during the ten-year evaluation. Similarly, Berger Paints was used 5 times, while Beta Glass Company, though operated efficiently in 2016 and 2017, respectively, was not used as a peer/reference for efficiency in any of those years. Nevertheless, Cadbury and Cement Company of Northern Nigeria were used 10 times and 9 times as peers/references for efficiency in the course of the assessments. It therefore follows that Dangote Sugar was the most efficient firm, while B.O.C Gases was the second most efficient firm between 2008 and 2017. Also, Cadbury, Cement Company of Northern Nigeria and African Paints were the third, fourth and fifth most efficient manufacturing firms, while A. G. Leventis was the least efficient firm during the period under consideration. The summary of peers and references as well as the DMUs efficiency ranking are reported in Table 3. Figure 3 reports the summary of Peer and Reference (Total), while Figure 4 shows the summary of Peer and Reference (total) & Efficiency Ranking.

Table 3: Summary of Peer and Reference

DMUs	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*Peer Total*	*DMUs Efficiency Ranking*
7Up Nigeria	-	-	-	-	-	-	-	3	1	-	4	7th
A. G. Leventis	-	-	-	-	-	-	-	-	-	-	0	10th
Dangote Sugar	3	1	3		2	2	2	1	1	1	16	1st
African Paints	-	-	1	1	2	-	1	-	-	1	6	5th
Aluminium Extrusion Industry	1	-	-	-	-	-	-	1	-	-	2	8th
B.O.C Gases	3	2	3	2	1	1	1	1	1	-	15	2nd
Berger Paints	-	-	-	-	1	1	-	2	-	1	5	6th
Beta Glass Company	-	-	-	-	-	-	-	-	-	-	0	9th
Cadbury Nigeria	-	-	1	-	3	3	1	-	1	1	10	3rd
Cement Company of Northern Nigeria	1	2	1	1	-	2	1	1	-	-	9	4th

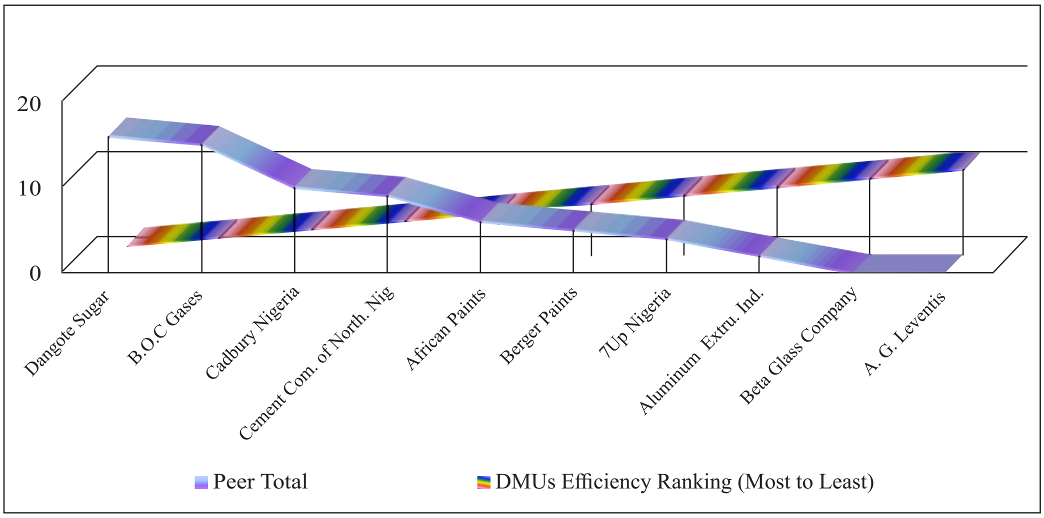
Source: Authors' Computation

Figure 3: Summary of Peer and Reference (Total)



Source: Authors' Computation

Figure 4: Summary of Peer and Reference (total) & Efficiency Ranking



Source: Authors' Computation

V. Conclusion and Recommendations

The study empirically assessed the efficiency of some selected firms in the Nigerian manufacturing sector, using output-oriented multi-stage based variable returns to scale (VRS) Data Envelopment Analysis (DEA) approach. Findings from the study revealed that, the Nigerian manufacturing sector was 60 per cent efficient in 2008 and 2009 respectively, 70 per cent and 80 per cent in 2010 and 2011, 70 per cent in 2012 and 2013 respectively, 80 per cent in 2014 and 2015 respectively and 90 per cent in 2016 and 2017 respectively. The result of the efficiency ranking further revealed that, Dangote Sugar was the most efficient firm, while B.O.C Gases was the second most efficient firm between 2008 and 2017. Also, Cadbury, Cement Company of Northern Nigeria and African Paints were the third, fourth and fifth most efficient manufacturing firms, while A. G. Leventis was the least efficient (most inefficient) firm during the period under consideration.

The study therefore recommends that the inefficient firms should carefully adopt an optimal input mix in order to cut cost and improve outputs. The discussion on the Peers and Lambdas of the output-based orientation in sub-section 4.2 can serve as a reference guide or model to the inefficient firms desiring to achieve efficiency. Similarly, intra-industry merger and acquisition can be considered in the instance of protracted inefficiency in the system, as it was in the case of A. G. Leventis, since the findings revealed that DMUs in this form suffered inefficiency throughout the period of analysis. This could be as a result of poor management, toxic assets of the firm, or negative influence of ownership. This is the basis of the M&A recommendation aimed at boosting the performance and efficiency of such firms in particular and, by extension, the overall efficiency level of the Nigerian manufacturing sector. And, given the pivotal role of the manufacturing sector in modern day economies, an efficient manufacturing sector in the Nigerian context will invariably promote the much-desired rapid industrial transformation of the Nigerian economy.

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