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The Technical Efficiency of Manufacturing Companies on the Nigerian Stock Exchange

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Abstract

The objective of the study is to establish whether quoted manufacturing companies in Nigeria are operating on the production possibility frontier, that is, if they are technically and scale efficient. In pursuance of this, the study adopted the output orientated DEA with input variables as total asset, shareholder's equity, cost of goods sold and operating expenses, while the output variables are sales/turnover, net profit, return on asset, and return on equity. Output orientated DEAP Version 2.1 package with variable return to scale assumption using multi-stage DEA is employed. 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 selected for the study are operating on production possibility frontier while the remaining twenty-seven companies are not. It is 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.

JEL classification numbers:
Keywords: Technical Efficiency, Manufacturing, Stock Exchange

1 Introduction

The inefficiency of the Nigerian manufacturing sector over the last four decades shows that there are some important problems that acted, and are still acting as barriers to the growth of this sector (Nigerian Stock Exchange, 2010). As important as the manufacturing sector is to the growth of the Nigerian economy, available statistics still show that the sector only contribute marginally to the Gross Domestic Product (GDP). A review of the performance

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of the industrial sector in the year 2009 indicated that capacity building declined from 46.7 percent at the beginning of the year to 42.4 percent as at the end of year 2010. According to the Central Bank of Nigeria (2010), the estimated index of manufacturing production, which stood at 86.4% as at December 2009, indicated a decline of 3.7% from the preceding year's level of 89.7%. These challenges included late release of the 2009 budget, poor power supply, infrastructural bottlenecks, insecurity of lives and properties, high lending rates, inefficient deployment of resources, shortage of labour, multiple taxation and levies, and lack of patronage of locally manufactured products. The poor performance led to the near collapse of the manufacturing sector. 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. The prevailing energy crisis contributed to low performance. "Vision 2020" which seeks to make Nigeria one of the strongest economies in the world by 2020 cannot be achieved if in 2011, just 9 years to 2020, industries particularly labour-intensive industries are producing at low capacity. All these indicate that the efficiency of the Nigerian quoted manufacturing companies is in doubt.

Various studies have been conducted to measure technical efficiency of manufacturing sector in Nigeria; among the studies are Soludo and Adenikinju (1996), Adenikinju (1996), Chete and Adenikinju (1996), Egbon (1995) and Adewuyi (2006). 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. These studies include: Diaz and Sanchez (2008), Mahedevan (2010), Fare, Grosskopf and Margaritis (2001), Bjurek and Duravell (2002), Nordin and Said (2010), Arzu and Tosun (2010), and Ephraim (2000). Despite the long list of research papers on technical efficiency of manufacturing companies using DEA, its appearance and impact on quoted manufacturing companies especially in developing countries such as Nigeria is limited. This study is an attempt to fill this lacunae.

2 Literature Review

Technical Efficiency

Technical efficiency is the ability of a firm to maximize output level from a given input level (Farrell, 1957; Debreu 1951 and Koopman, 1951). These concepts combine to yield economic efficiency, and technical efficiency is only an integral part of overall economic efficiency.

Efficiency can also be considered to be input or output orientated. It is input orientated, when it is seen in the light of the optimal mix of input to obtain a given level of output, and it is output orientated when it is seen in light of optimal output. The measurement of a firm specific technical efficiency is based upon deviation of observed output from the best production or efficiency production frontier. If a firm's actual production point lies on the frontier, it is perfectly efficient. If it lies below the frontier then it is technically inefficient with the ratio of the actual to potential production defining the level of efficiency of the individual firm (Herero & Pascoe, 2002).

Types of Technical Efficiency Measures

The various forms of technical efficiency measures include:

Constant Returns to Scale: The constant returns to scale model assumes strong disposability of inputs (*s*) and constant returns to scale (*c*). Strong or free disposability refers to the ability to stockpile or dispose of unwanted commodities. The linear programme minimizes θ which determines the amount by which observed inputs can be proportionally decreased if they are utilized efficiently. We solve the following:

$$OTE_{j0}(y, x \mid C,S) = \text{Min } \theta \quad (1)$$

$$\sum_{j=1}^{n} w_j x_{ij} \leq \theta x_{ij0} \quad i = 1 \ldots s$$

$$\sum_{j=1}^{n} w_j y_{rj} \geq y_{rjo} \quad r = 1 \ldots m$$

$$w_j \geq 0$$

where OTE_{jo} (y,x | C,S) is the overall technical efficiency of the firm j_0, θ is the measure of technical efficiency, y_{rj} denotes output *r* (*r*=1 … s) for the *j* th firm, x_i denotes input *I* = (*i*=1…,*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 for output orientated measures.

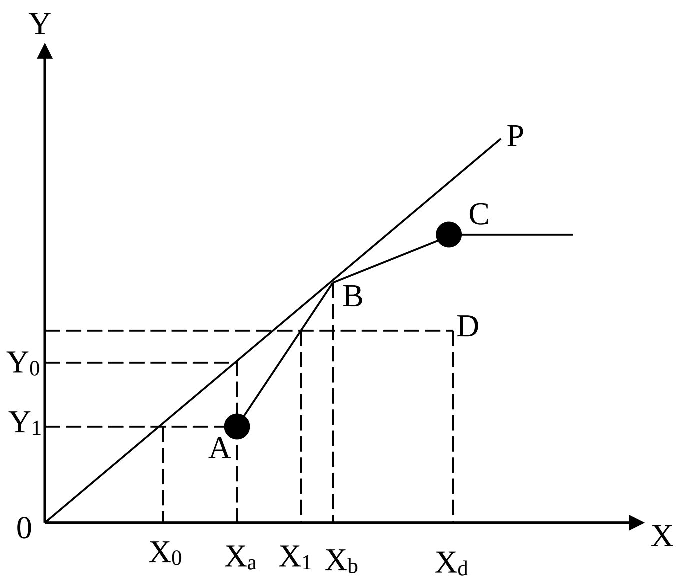

Figure 1: Data Envelopment Analysis Efficiency Measures

Variable Returns to Scale

We illustrate the DEA technique in Figure 1 with one output and one input and four firms A, B, C and D. Under constant returns to scale and strong disposability, the frontier technology constructed by the observations is represented by the ray from the origin through point B. In the input orientated measure of efficiency, only B is efficient since it is

on the frontier. Firm A is not efficient since output at point A can potentially be produced by a smaller quantity of input x_0 rather than x_a ($x_0 < x_a$) and its efficiency level is calculated as $x_0/x_a < 1$.
We relax the assumption of constant returns to scale for estimating overall efficiency to obtain efficiency under variable returns to scale (*v*), while maintaining the assumption of strong disposability of inputs (*s*) following Banker, Charnes and Cooper (1984). The reference technology in Figure 1 is bounded by $x_a ABC$ and the horizontal line to the right of C and the x-axis from x_a to infinity. This implies that firms A, B and C are fully efficient, while the efficiency of D is measured by the ratio x_1/x_d, which is less than one and below the frontier. Imposing a further restriction on the weights relaxes the assumption of constant returns to scale. The resulting linear programme derives the input orientated weak efficiency measure under variable returns to scale:

$$WTE_{jo}(y, x \mid V, S) = \text{Min}\ \theta \qquad (2)$$

Subject to a further restriction in (1)

$$\sum_{j=1}^{n} w_j = 1$$

We calculate another input orientated measure of technical efficiency under the assumption of non increasing returns to scale (*N*) and strong disposability of inputs (*S*) (Fare, Grosskopf, Norris & Zhang 1994; Bjurek, Hjalmarsson & Forsund, 1990). We solve the linear programme in (2) to obtain a weak efficiency measure under non increasing returns to scale by imposing a further constraint. Thus,

$$WTE_{j0}(y, x \mid N, S) = \text{Min}\ \theta \qquad (3)$$

Subject to an additional constraint in equation (1)

$$\sum_{j=1}^{n} w_j \leq 1$$

The technology for WTE_{jo} (y, x | C, S) in Figure 1 is bounded by the x-axis and OBC and the horizontal line to the right of C. Thus, point A which is efficient under variable returns to scale and strong disposability is inefficient under non increasing returns to scale and strong disposability of inputs. Points B and C, are technically efficient both under variable returns to scale and non increasing returns to scale.

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

$$STE_{jo}(y, x) = \frac{OTEjo\ (y,x \mid C,S)}{WTE_{jo}\ (y, x \mid V, S)} \quad j = 1,2 \ldots J \qquad (4)$$

Thus, firm *j* is input scale efficient if STE_{jo} (y, x) = 1 or if it is equally technically efficient relative to the (C, S) and (V, S) input set. The scale efficiency measures input loss due to operating at an inefficient scale. In Figure 1, only point B is scale efficient while points A, C, and D are scale inefficient since they could produce the same output with fewer inputs if they operated on an efficient scale (the difference between non constant returns to scale technology and the constant returns to scale technology).

These measures of efficiency enable the identification of the types of returns to scale in production for a particular firm. We have constant returns to scale if $OTE_{j0}(y, x \mid C, S) = WTE_{jo}(y, x \mid V, S)$. This is satisfied at point B. If $WTE_{j0}(y, x \mid N, S) = WTEjo(y, x \mid V, S) \neq OTE_{j0}(y, x \mid C, S)$, then the unit under consideration produces at decreasing returns to scale. The firm at point C produces at decreasing returns to scale. Finally, production takes place at increasing returns to scale if $WTE_{jo}(y, x \mid V, S) \neq WTE_{jo}(y, x \mid N, S)$ such as at points A and D. In all the above types of technical efficiency, production is technically efficient if the measure of efficiency is equal to unity. If we have technical inefficiency, the corresponding measures will be less than one. The differences between unity, and observe measure yield the percentage of potential input savings that the firm could make due to the particular type of inefficiency.

The Concept of Efficiency and its Measurement: Efficiency is a multi-faceted concept that deals with the ability of an agent to make use of a given measure of input to produce a maximum possible unit of output at the required time. Efficiency is made up of technical and allocative efficiency. Technical efficiency looks at the ability of the decision making units to combine minimum possible input to produce maximum possible output, while allocative efficiency looks at cost minimization of the input employed (Mainak, Meenakshi & Ray, 2009). The economic theory underlying efficiency analysis dates back to the work of Koopmans (1951), Debreu (1951), and Farrell (1957). The presence of inefficiency can be attributed to differences in production technology, differences in the scale of operation, differences in operating efficiency and differences in the operating environment (Fried, Lovell & Schmidt,1994). Leibenstein (1966) defines the production process of any unit, which may be influenced by economic factors internal to any firm and other factors not tightly under the control of the management. Proper attribution is important for the adoption of managerial practices and the design of public policies intended to improve productivity performance.

The measurement of economic efficiency has been intimately linked to the use of frontier functions. Modern literature begins with the same work of Farrell (1957). Farrell (1957) greatly influenced by Koopmans (1951)'s formal definition and Debreu (1951)'s measure of technical efficiency introduced a method to decompose the overall efficiency of a production unit into its technical and allocative components. A productive unit can be inefficient either by obtaining less than the maximum output available from a determined group of inputs (technically inefficient) or by not purchasing the best package of inputs given their prices and marginal productivities (allocatively inefficient). Fare and Lovell (1978) point out that, under CRS, input orientated and output orientated measures of technical efficiency are equivalent. Such equivalence as Forsund and Hjalmarsson (1979) and Kopp (1981) state, ceases to apply in the presence of non-constant returns to scale.

Efficiency measurement is one aspect of a company's performance. A company is regarded as technically efficient if it is able to obtain maximum outputs from given inputs or minimize inputs used in the production of given outputs. The objective of producers is to avoid waste (Simone, 2008). Theoretically, measurement of productive efficiency is necessary because it will yield an empirical value of the relative efficiency of different productive systems while for the sake of effective economic planning, it will be important to know the proportion by which output could be increased by increasing efficiency without any further addition to input usage (Simone, 2008).

Figure 2 below shows the hypothetically efficient production function which is represented by the isoquant qq^1. It is assumed to be the estimated production function representing the isoquant based on its ability to fulfill the assumptions that it is convex and that the slope is no where positive. On the fulfillment of this, qq^1 forms the most exacting standard of efficiency that is consistent with the observed points (Farrell, 1957, and Koopmans, 1951).

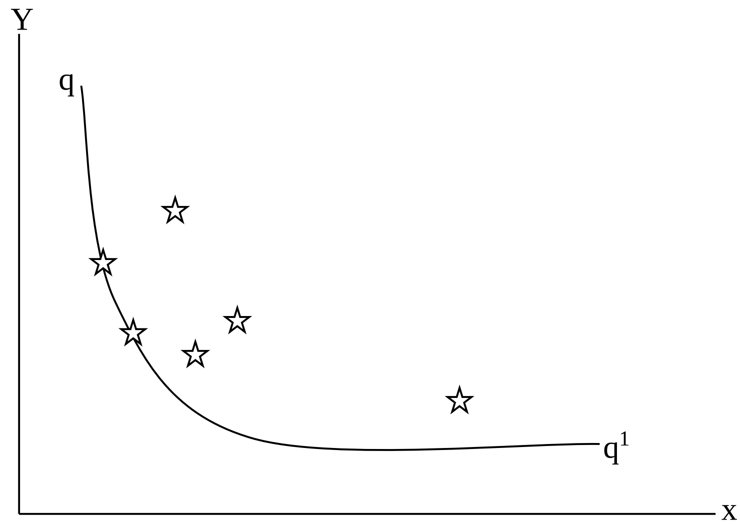

Figure 2: Isoquant and Production Points of Hypothetical Firms

The convexity axiom implies that if two points are attainable in practice, it also follows that any point representing a weighted average of them is also attainable. With constant returns to scale the processes represented by the two points could be carried on without interference with each other. The second axiom that the slope of the isoquant is no where positive holds to ensure that increased application of the inputs would accordingly result in increased output. Hence qq^1 is taken as the estimate of the efficient isoquant. This method of measuring technical efficiency involves selecting a hypothetical firm with the factor input in the same proportions. The hypothetical firm is constructed as a weighted average of two observed firms, in the sense that each of its inputs and outputs is the same weighted average of those of the observed firms (Farrell, 1957, and Debreu, 1951).

Empirical Studies of DEA Application in Manufacturing Companies

Numerous studies on efficiency and performance using DEA have been conducted and reported in assessing industrial performance. Al-Shammari (1999) applies the modified model of DEA to evaluate the operational efficiency of fifty-five Jordanian manufacturing shareholding companies listed in the Amman Financial Market (AFM) using financial data for the year 1995. Zhu (2000) developed a multi-factor performance model companies in 1995. A market efficiency study on top listed companies in Egypt was conducted by Mostafa (2007) using a two-stage approach. Their study shows that technical efficiency rises with company size and that there is a sustainable change in the distribution of efficiency across company sizes with some companies operating at the same or higher levels of efficiency than some large companies.

3 Methodology

The population of the study comprises of all quoted manufacturing companies on the Nigerian Stock Exchange. The study therefore focuses on the eighty-six manufacturing companies. The study adopted stratified random sampling. From each sector, each company was selected randomly based on the relative proportion of the population represented by each sector.

Due to its non-parametric and multi-dimensional nature, DEA approach generally requires large numbers of DMUs to produce statistically meaningful results (Simar & Wilson, 2000). Therefore, DEA is highly vulnerable to data problems. From the population of eighty-six companies identified as manufacturing companies, eighteen companies have no financial record for some of the years under study. These companies were excluded because DEA does not accept dummy variables. The population of the study became sixty-eight companies, out of which the sample size of fifty-eight companies was chosen. The larger the sample size, the better it is for DEA estimation (Smith, 1997).

The study was based on 2004 to 2010 secondary data obtained from Nigerian Stock Exchange Factbooks, Annual reports and financial statements of the companies under study. The input variables of the companies are total asset, shareholder's equity, cost of goods sold and operating expenses while the output variables are sales/turnover, net profit, return on asset and return on equity.

The study adopted output orientated DEA with variable return to scale (VRS) assumptions using multi-stage DEA approach. The data were analyzed with output orientated DEAP Version 2.1(Coelli,1996). This package was employed to analyze the production possibility frontier-technical and scale efficiency of the companies.

4 Analysis of Results and Discussion of Findings

Data Envelopment Analysis Results: The technical and scale efficiency scores of quoted manufacturing companies in Nigeria between 2004 and 2010 are shown below.

Table 1: Technical and Scale Efficiency Scores of Quoted Manufacturing Companies in Nigeria (2004-2010).

S/N	DMU(COMPANIES)	Constant Return to Scale Technical Efficiency	Variable Return to Scale Technical Efficiency	Scale Efficiency	Remarks
1	LIVESTOCK	0.699	0.699	1.000	CRS
2	FTN COCOA	0.334	1.000	0.334	DRS
3	PRESCO	1.000	1.000	1.000	CRS
4	OKOMU	1.000	1.000	1.000	CRS
5	GUINNESS	0.313	0.554	0.565	DRS
6	NIG. BREW	0.891	0.923	0.966	DRS
7	INT. BREW	1.000	1.000	1.000	CRS
8	ASHAKA	0.131	0.579	0.226	DRS
9	CEMENT CO.	1.000	1.000	1.000	CRS
10	LARFARGE	1.000	1.000	1.000	CRS
11	NIG. ROPES	1.000	1.000	1.000	CRS
12	AFRI. PAINTS	0.376	0.520	0.723	DRS

13	BERG. PAINTS	0.309	0.873	0.354	DRS
14	CAPL	0.196	0.770	0.255	DRS
15	IPWA	0.305	0.984	0.310	DRS
16	PREM. PAINT	1.000	1.000	1.000	CRS
17	NCR	0.965	1.000	0.965	DRS
18	THOMAS	1.000	1.000	1.000	CRS
19	TRIP GEE	1.000	1.000	1.000	CRS
20	LEVENTIS	1.000	1.000	1.000	CRS
21	CHELLARMS	1.000	1.000	1.000	CRS
22	P.Z	0.641	1.000	0.641	DRS
23	SCOA	1.000	1.000	1.000	CRS
24	UNILEVER	0.243	0.948	0.257	DRS
25	CUTIX	1.000	1.000	1.000	CRS
26	NIG. WIRE	0.095	0.979	0.097	DRS
27	7-UP	0.293	0.966	0.304	DRS
28	CADBURY	0.174	0.675	0.257	DRS
29	FLOUR MILL	0.649	0.672	0.966	DRS
30	NAT. SALT	1.000	1.000	1.000	CRS
31	NORTH FLOUR	1.000	1.000	1.000	CRS
32	NESTLE	0.422	0.556	0.759	DRS
33	NIG. BOTTLING	0.622	0.930	0.669	DRS
34	P.S. MAND	0.536	1.000	0.536	DRS
35	UTC	1.000	1.000	1.000	CRS
36	GLAXO	0.242	0.254	0.952	IRS
37	M & BAKER	0.738	1.000	0.738	DRS
38	MORISON	1.000	1.000	1.000	CRS
39	NEIMETH	0.109	0.193	0.562	DRS
40	PHARMA	1.000	1.000	1.000	CRS
41	ALUM. EXTR	1.000	1.000	1.000	CRS
42	B.O.C.GAS	0.127	0.296	0.429	DRS
43	NIG. ENAL	0.265	0.689	0.384	DRS
44	VITAFOAM	1.000	1.000	1.000	CRS
45	AVON	1.000	1.000	1.000	CRS
46	BETA	1.000	1.000	1.000	CRS
47	NAMPAK	0.195	0.696	0.280	DRS
48	NIG. BAG	1.000	1.000	1.000	CRS
49	GREIF	0.470	0.701	0.671	DRS
50	POLY	0.988	1.000	0.988	DRS
51	MRS OIL	0.298	0.541	0.552	DRS
52	CONOIL	0.364	0.366	0.995	IRS
53	ETERNA	0.393	0.423	0.929	DRS
54	MOBIL	0.174	0.758	0.230	DRS
55	ACADEMY	1.000	1.000	1.000	CRS
56	LONGMAN	0.318	0.926	0.343	DRS
57	UNIPRESS	0.810	0.901	0.900	DRS
58	UNT.TEXT	1.000	1.000	1.000	CRS
	Mean	**0.667**	**0.851**	**0.761**	

Source: DEA print out

Table 1 above shows the technical and scale efficiency scores of quoted manufacturing companies in Nigeria. The sampled mean of the company technical efficiency under variable return to scale score of 85% and a scale efficiency score of 76% shows that the Nigerian quoted manufacturing companies are relatively efficient. Thirty-one companies out of the fifty-eight (53%) companies were technically efficient while twenty-seven (approximately 47%) companies were technically inefficient because they had technical efficiency score below 100% under variable return to scale assumption. The technical inefficiency score among the inefficient companies ranged from 19% to 98% in Neimeth and IPWA. This implies that these companies need to scale down input by 81% and 2% respectively to produce the same level of output since they both exhibited decreasing return to scale. The scale efficiency analysis result shows that twenty-six companies out of the fifty-eight companies had scale efficiency scores of 100% while thirty-two companies had scale efficiency score of less than 100%. This means that 45% of the sampled companies had most productive scale size for the input-output mix while 55% of the companies are scale inefficient. The thirty-one companies that operated on the production possibility frontiers, twenty-five companies exhibited constant returns to scale. There was an exception in livestock, which exhibited constant return to scale despite the fact that it is technically inefficient. This implies that this company operated on productive scale size with appropriate utilization of input. In other words apart from the fact that the thirty-one companies are technically efficient, operated on the production possibility frontiers, twenty-five of them exhibited constant return to scale. This shows that they operated at their most productive scale size while the remaining six companies exhibited decreasing return to scale which means that the input factors were over employed despite the fact that they are efficient.

Among the inefficient companies twenty-four companies revealed decreasing returns to scale (DRS) while the remaining two companies revealed increasing returns to scale (IRS). A DMU (companies) is said to be operating under decreasing return to scale if changing all inputs by the same proportion results in a smaller proportional change in outputs. What this implies is that in these companies that exhibited decreasing returns to scale, they had input factors over employed. Therefore there is no careful usage of factor input. In fact more than their present level of output attainment can be achieved by less than their current level of input consumption while the other two companies displayed increasing return to scale (IRS). A DMU (companies) is said to be operating on under increasing return to scale if changing all inputs by the same proportion results in a smaller proportional change in outputs. This implies that these companies input factors are under employed. These companies need to increase their quantity of factors input employment. This also shows that the inefficiency in the affected companies could be attributed to inadequate factor input and hence there is serious need for employment of more factor inputs. This also implies the tendency of the companies to overuse their current input factors. Therefore, in order to operate on the most productive scale size, the DRS companies should reduce input consumption while the IRS companies should increase input usage and expand output to enable them arrive at most productive scale size.

4.1 Discussion of Findings

Production Possibility Frontier: Technical efficiency refers to the extent to which the output of a decision making unit is being able to maximize for a given amount of productive inputs. In other words, production possibility frontier is when decision making unit is operating on the production possibility frontier (efficient frontier). From the sampled of fifty-eight companies in the study, thirty-one companies are operating on the production possibility frontier. This confirms the study by Mostafa (2007), Ephraim (1998), Mahmood, Ghani and Din (2007) and Ray (2002). Twenty-seven companies are not operating on the efficiency frontier (inefficient). This finding is in agreement with the study of Wu (2005). The efficient companies operated in the region of constant return to scale except livestock which is inefficient under variable return to scale but operated in constant return to scale; this means that the company is scale efficient, which also means that it operated on productive scale size. Some of the companies that are efficient under variable return to scale are also operating in the region of decreasing return to scale. The variable return to scale test suggests that the inefficient companies are operating in the region of decreasing return to scale. The increasing return to scale test also suggests that two companies are operating in the region of increasing return to scale. Specifically, twenty-six companies are operating in the region of constant return to scale; thirty companies are operating in the region of decreasing return to scale while two companies are operating in the region of increasing return to scale. These findings are in agreement with the findings by Zhu (2000) and Ku, Ahmad and Izah (2010).

Policy implication of the study: The efficient companies in the same sector should merge with the inefficient ones in order to enjoy the advantages of economies of large scale. For example, the inefficient companies in the Health sector could merge with the efficient ones or the efficient companies could acquire the inefficient ones to optimize resource use. This merger proposal is more appropriate within sector not between sectors, except to form conglomerate. For example, companies in the Breweries sector may not merge or acquire companies in the Petroleum sector but they can invest in each other.

5 Conclusion

The study utilized a strictly output orientated DEA methodology to measure the technical efficiency of quoted manufacturing companies in Nigeria under the assumption of variable return to scale. The results revealed that out of fifty-eight companies, thirty-one companies were found to be relatively efficient under variable return to scale assumption while twenty-five companies were technically efficient under constant return to scale assumption and twenty-six companies were scale efficient with multiple most productive scale size. The results further revealed that all the efficient companies under variable return to scale exhibited constant return to scale except livestock, others exhibited decreasing return to scale and only two companies exhibited increasing return to scale. The policy implication of these analyses is that it provides government the necessary information about the manufacturing companies so as to enable them formulate policies favourable to the companies in terms of tax relief and holiday, patronization of home made goods and proper administration of the ports.

References

[1] Adenikinju, A.F. (1996). Structural adjustment programme and productivity efficiency in the Nigerian manufacturing sector. *Nigerian Economic Society,* Selected Papers for the 1996 Annual Conference, August.

[2] Central Bank of Nigeria Statistical Bulletin, 2010 Issues.

[3] Chete, L & Adenikinju, A.F. (1996). Productivity growth in Nigerian manufacturing and its correlation with trade policy regimes/indices. *Research for Development*,*11*(1&2).

[4] Diaze, M.A., & Sanchez, R. (2008). Firm Size and Productivity in Spain: A Stochastic Frontier Analysis. *Small Business Economics, 30,* 315-323.

[5] Ephraim, W.C. (2000). Privatization and technical efficiency, evidence from Malawi Manufacturing, Department of Economics University of Malawi, *Working Paper No. WC/03/00.*

[6] Ephraim, W.C. (1998). Technical efficiency in manufacturing industries in Malawi using deterministic production frontiers. Department of Economics, University of Malawi, *Working Paper No. WC/05/98.*

[7] Fried, H., Lovell, C.A.K., & Schmidt, S.E. (1994). The measurement of productive efficiency: Techniques and applications. London: Oxford University Press.

[8] Forsund, F.R., & Sarafoglu, N. (2000). On the origin of data envelopment analysis. *Memorandum No. 24/2000*, Department of Economics, University of Oslo.

[9] Forsund, F.R., & Hjalmarsson, L. (1979). Generalized Farrell measures of efficiency: An application to milk processing in Swedish dairy plants. *The Economic Journal, 89,* 294-315.

[10] Fare, R. Grosskopf, S., & Margarittis (2001). Productivity in trend in Australian and New Zealand manufacturing. *Australian Economic Review, 34* (2), 125-134.

[11] Herrero, I., & S. Pascoe. (2002). Estimation of technical efficiency: A review of some of the stochastic frontier and DEA software. *Computer in Higher Education Review, 5*, 12 – 39.

[12] Imafidon, K. (2012). Assessing the efficiency of quoted manufacturing companies in Nigeria: Data envelopment analysis approach. A Ph.D thesis submitted to the Department of Business Administration, University of Benin, Benin City.

[13] Koopmans T.C. (1951). (Ed) Activity analysis of production and allocations. New York: Wiley.

[14] Koopmans, T.C. (1951). Analysis of production as an efficient combination of activities in T.C. Koopmans, (ed). New York: Wikley.

[15] Kopp, R.J. (1981). The measurement of productivity efficiency: A reconsideration. *Quarterly Journal of Economics*, *96*, 477-503.

[16] Ku, N, Ahmad, M., & Isah, Y, M. (2010). An evaluation of company operation performance using data envelopment analysis approach: A study of Malaysian public listed companies. *International Business Management, 4* (2), 117-52.

[17] Leibenstein, H. (1966). Allocation efficiency vs. x-efficiency. *American Economic Review, 56* (3), 392-415.

[18] Mainak, M, Meenakshi, R., & Ray, S.C. (2009). Output and input efficiency of manufacturing firm in India: A case of the Indian pharmaceutical sector. *Institute for Social & Economic Change,* Banglove.

[19] Mahedevan, R. (2000). How technically efficient is Singapores manufacturing industries?. *Applied Economics Letter, 32*, 2007- 2014

[20] Mahedevan, R. (2010). Assessing the output and productivity growth of Malaysia manufacturing sector *Journal of Asian Economics, 12* (4), 587 – 597.
[21] Mostafa, M (2007). Evaluating the comparative market efficiency of top listed companies in Egypt. *Journal of Economics Studies, 34* (5), 430 – 452
[22] Nordin, M., & F. Said. (2010). Measuring the performance of 150 largest listed companies in Malysia. *African Journal of Business Management, 4* (13), 3178 – 3190.
[23] Nigerian Stock Exchange Factbooks, 2010 issues
[24] Smith, P. (1997). Model misspecification in data envelopment analysis. *Annals of Operations Research, 73,* 233-252.
[25] Simone, G. (2008). *The measurement of productivity and efficiency: Theory and Applications:* University of Rome, Italy.
[26] Soludo, C.C., & Adenikinju, A.F. (1996). Economic policy and total factor productivity in Nigeria's manufacturing sector. Final Report Submitted to the Dev. Centre .OECD, Paris.
[27] Zhu, J. (2000). Multi-factor performance measure model with an application to fortune 500 companies. *European Journal of Operation Research, 123,* 105 – 124.