9 APPLICATION OF LEONTIEF INPUT-OUTPUT MODEL IN MANUFACTURING SECTOR IN NIGERIA

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ABSTRACT
The study applied the Leontief input-output relationship of nineteen manufacturing companies in Nigeria. The objective of the study is to investigate the extent of the interdependence between companies in the Nigerian manufacturing sector, and to determine the input-output relationship of the manufacturing sector in Nigeria. The study also examined the extent of scale efficiency of the manufacturing sector in Nigeria and the extent of technical efficiency of the manufacturing sector in Nigerian. The study used longitudinal research design by selecting some quoted manufacturing companies in the Nigerian Stock Exchange for the period 2011 to 2015. Data Envelopment analysis (DEA) was used for the empirical analysis. The result showed that there is a relationship between inputs and outputs, Chemical and Allied Product (CAP), Cutix, Dangote Cement and Greif were efficient under constant return to scale (CRS) after taking five years average inputs and outputs to sustain its efficiency within the period. While Aluminium Extrusion Industries, Chemical and Allied Product, Cutix, Dangote Cement, Dn Meyer, Greif Nigeria, Ipwa, Nigeria Ropes, Nigerian Enamelware, Paints and Coatings Manufacturers, Portland Paints and Premier Paints were scale efficient and technically efficient among the nineteen manufacturing companies sampled. The study therefore recommends that management and concerned authorities of the manufacturing companies in Nigeria should ensure that the manufacturing sectors are technically efficient. The study also suggests that the government should provide a platform for the inefficient manufacturing companies by formulating policies favourable in terms of tax relief and holiday for productive efficiency of the sector.

Keywords: *Data Envelopment Analysis, Manufacturing Sector, Technical Efficiency, Scale Efficiency.*

1.0 INTRODUCTION

Manufacturing sector is instrumental to the advancement of any nation particularly the developing countries. The advancement of manufacturing sector serves as major instrument of growth, critical condition for full employment, creation of wealth and major tool for sustainable economic advancement (Wachukwu, 2013). In the opinion of Olorunfemi, Tomola, Felix and Ogunleye, (2013), Efayena, Enoh & Patricia (2018). the manufacturing sector has major setback because of undesirable business environment due to the fact that the environment is a major source of all inputs required for the operations and activities of the firm. The inputs are usually in form of manpower, money, materials, machines and information (Okwo & Ugwunta, 2012). The environment also absorbs the manufacturing output. Generally, goods manufactured by the business are used in the environment based on the conditions of industrial development (Dickson, 2010). This environment may be either within or outside the boundaries of a country (Dickson, 2010). Leontief (1966) uses a matrix table format analysed ways of combining economic factors and theory in an economy, especially the manufacturing sector. The input-output theory is a quantitative analysis which explained the relationship between two or more industries with the aim of allocating resources in multi-sectoral economy. Miller, Karen, Polenske and Adam, (1989) opined that explaining the relationship between the inter-industry indicated the links which exist between the manufacturing sectors in any economy. The Kaldorian theory was developed in 1957 to provide detailed explanation on the relationship between different manufacturing output growth and economic growth. This theory further explained that the relationship between manufacturing output growth and economic growth plays significant role in the growth performance of a nation economy. That is, it has the feature of increasing returns to scale of any economy (Nancy, 1992). The focus of Leontief input-output analysis is on the flow of inputs and outputs among the different manufacturing companies. Meanwhile, Data Envelopment Analysis (DEA) estimates the relative technical and scale efficiency of the Leontief input-output analysis been a mathematical programming technique (Charnes, Cooper, Lewin & Seiford, 1994). Ogundari, Ojo and Ajjibefun (2006), Benjamin, Joseph & Simon (2017) observed that DEA analysis helps to evaluate the firm's scope, scale technical and allocative efficiency of firms in Nigeria. Kirkley, Fare, Grosskopf, McConnell, Strand and Squires (2000) cited that DEA analysis assists the firm to evaluate standards and total quality management structures, efficient utilization of input, productivity and capacity utilization assess both private and social cost of outputs and examine the activities of the strategic groups. In addition, data envelopment analysis examines the relationship between inputs and outputs. Based on the foregoing, this study seeks to focus on the application of

the Leontief input-output model in the manufacturing sector.

1.1 Statement of the Research Problem

The state of manufacturing companies and industrial development in Nigeria is an indication of how Nigeria has totally abandoned the sector due to emphasis placed on oil discovery in the country including unstable government policies and programmes (Adeola, 2011). Adenikinju and Alaba (2000) argued that low industrialization became more prominent due to absence of locally sourced raw material in the country. High production cost, heavy duties, high cost of energy, poor infrastructural base and high cost of importation are some of the problems of manufacturing sector (Akinmulegun & Oluwole, 2013). Eze and Ogiji (2013) observed that most manufacturing industries in Nigeria are critically faced with problems such as issues of corruption, poor implementation and inappropriate policies frameworks engineered by lack of coordination of economic plans, misappropriation of public funds and poor structuring of economic plans. Okemini and Uranta (2008) add that lack of economic potential for rapid economic growth and development, over dependence on input materials from abroad are militating factors against industrial development in Nigeria. Thus the poor operational and technical efficiency of the management brings about wastage of capital and human resources which are limited in supply to industrial development (Adeloye, 2010). In the same vein, the government has to identify appropriate techniques, policies or strategies that will help alleviate the problem of the manufacturing sector for sustainable economic growth and development (Akinmulegun & Oluwole, 2013).

Akpan, Ukoha, Onyenweaku and John (2012) examined links between technical efficiency, macroeconomic variables and industrial policy by providing evidence in sugar industry from 1970 to 2010 in Nigeria using regression analysis. Ogbo, Japheth and Ukpere (2014) adopted *a Chi-square statistical technique to ascertain the influence of global innovative collaboration on organizational efficiency of Nigerian Breweries Plc.* Tafamel and Akrawah (2015) conducted research on profitability and cost efficiency of the oil and gas companies in Nigeria adopting data envelopment analysis. Osamwonyi and Imafidon (2016) empirically investigated technical efficiency of manufacturing companies listed on the Nigeria stock exchange using output oriented DEA technique. In furtherance of their research Osamwonyi and Imafidon (2016), also examine if most manufacturing companies on the Nigeria Stock Exchange are operating on the production possibility frontier to know how technical and scale efficiency they are. To the best of our knowledge no empirical study has been conducted in Nigeria that applied Leontief input-output analysis to carry empirical analysis. Based on these statements, this study intends to fill the above gap by employing the Data Envelopment Analysis (DEA) to empirically examine the Leontief input-

output analysis of the manufacturing sector in Nigeria**.** The study also expanded the body of knowledge on the area of the Leontief input-output analysis .

1.2 Objectives of the Study

The broad objective was to apply the Leontief input and output relationship in the manufacturing sector in Nigeria. The specific objectives were to:

(i) investigate the extent of the interdependence among industries in the Nigerian manufacturing sector.
(ii) determine the input-output relationship of the manufacturing sector in Nigeria.
(iii) examine the extent of scale efficiency of the manufacturing sector in Nigeria.
(iv) determine the extent of technical efficiency of the manufacturing sector in Nigeria.

1.3 Research Hypotheses

The following hypotheses were formulated in a null form:

H_{o1}: there is no interdependence among industries in the Nigerian manufacturing sector.
H_{o2}: the input-output relationship of the manufacturing sector in Nigeria is not significantly related.
H_{o3}: the manufacturing sector in Nigeria is not scale efficient.
H_{o4}: the manufacturing sector in Nigeria is not technically efficient.

2.0 LITERATURE REVIEW

2.1 Overview of the Manufacturing Sector Performance

Manufacturing sector in Nigeria is the engine of growth that creates a potential platform for economic growth and development with the promising labour force (Akinmulegun & Oluwole, 2013). The term manufacturing is a broader term that establishes relationship between the quality and quantity of output and the right combination of inputs used to produce the right goods and services (Sharma, 1999). The manufacturing industry is primarily meant for the processing of domestic materials with the process of involving the imported inputs in the production process (Nor & Mohammed, 2014). However, the finished goods are made available to the potential buyers and consumers while the working process or intermediates goods are used for further production processes (Dickson, 2010). Efficient manufacturing process will be possible in an environment where there is good investment in efficient infrastructural facilities, availability of financial incentives from financial market and creation of enabling environment such as opportunities for firm's investment, good investment atmosphere to create jobs and increase the frontier of business activities (Malik, Teal & Baptist, 2004) According to Nor and Mohammad (2014) manufacturing is the process of transforming combined inputs into output. In the opinion of Vanish, Rajesh, Ray and Kural in (2013) the growth of manufacturing sector depends on the availability of factor of production such as capital and labour which depend on their efficiency and technical advancement which are the bases for productivity. The Nigerian manufacturing sector has been

operating under a harsh economic environment (Chima, 2012). Chima (2012) observed these problems to include poor state of infrastructural facilities, increase in cost of production, lack of access to financial resources, intense competition from imported goods and limited scope of operation. Akinmulegun and Oluwole (2013) observed that low level of purchasing power of customers, high level of sub- standard product, fake and cheap goods, dumping of all kind of products into the country all in the name of globalization, trade integration and liberalization of economic activities. These factors have contributed to the low consumption of locally manufactured products. The cost of financing depreciation of naira as against foreign currency is extremely high. More also, high cost of lending coupled with poor access to finances experienced by small businesses (Chima, 2012). Adeola (2011) observed that poor governmental policies and programmes are affecting the manufacturing companies. These policies are evidenced in high tax rate and multiple taxes. Omodele (2015) states that inadequate and inadequacy of the available infrastructural facilities is a factor creating a negative effect on the manufacturing sector's performance.

2.2 Interdependence among Industries in Nigerian Manufacturing Sector

Blanchard and Ripsman (1996) held that the extent to which the level of sensitivity of a firm's economic behaviour to procedures and advancement of firms externally with respect to its operating business environment is called interdependence among industries. Technological development among manufacturing firms and policies that encourage the economic growth of the country internally and global competition externally are attributed to economic interdependence (United Nation, 2015). Leontief (1966) model assumes that consumers and the households are given the same preference as other industries in an economy where the output received serves as input for producing other outputs such as manpower in the case of the household and other industries in the manufacturing sector. The machines used in the production processes served as inputs for the production of further outputs. This means that one or more components of final demands are treated endogenously while the personal consumption expenditures are known as the households in the sector activities (Leontief, 1966). Leontief (1966) is of the view that the inter-industry relationship in an economy is the proof that the output from one industrial sector serves as input in another industrial sector. The inter-industry matrix provides detailed explanation on input to a manufacturing sector on one column and outputs on the row on other side. It further provides explanation for the dependence and relationship of each sector, for example customers of outputs and suppliers of inputs. The monetary values of inputs are scaled against each column while the values of inputs are indicated against each row on the analysis.

2.3 Input-Output Relationship of the Manufacturing Sector in Nigeria

The Nigeria manufacturing sector is

characterized by large number of firms producing identical products and this is based on the production function (Loto, 2012). In addition, the main production function comprises capital and labour which are used in the production of goods and services (Libanio, 2006). On the main function of the manufacturing sector's exports in the process of maintaining economic growth is a framework of a straight-forward production function that classifies the manufacturing exports as a production input (Akpan, Ukoha, Onyenweaku & John, 2012). Dietzenbacher and Michael (2004) defined input-output model as a concept that provides quantitative explanation on the interdependence of different aspect of the economy. The input-output analysis is based on efficiency which is the relationship between output of goods and services and the input resources such as human and capital resources available in the production processes (Sofoluwe, 2000). The output is derived from the production of final goods and services. The inputs are labour and energy, capital, materials and time combined to produce the desired output. According to Ark (2007:15), 'the level of productivity is the output per unit of input with a close nominal cost savings'. The term productivity is technically defined as the relationship between outputs (sales, market shares) to inputs (labour hours, cost of production, equipment). Labour cost is a manufacturing operating expenses. Cost and availability of labour have been major factors in manufacturing investment decisions (McGranahan, 2000). Okwo and Ugwunta (2012) are of the view that input is known as raw materials, labour, investments in fixed assets, taxes, interest rates and changes in foreign exchange rate. Input cost is divided into direct and indirect cost. The direct costs are the costs that can be traceable to a particular unit of production or services while the indirect costs are those cost that are not directly traceable to any particular unit of production (Okwo & Marire, 2012). Inputs are indirect costs which are also overhead costs of production not related to a particular unit of production but cost incurred in the running of the operation of business organizations (Omolehinwa, 2000).

Production measures the efficiency in which inputs such as labour, material and support services are converted into output (Banker & Datar, 1987). The two outputs produced are denoted as Y_1 and Y_2 written in a vector form as Y = (Y_1, Y_2), *the physical* inputs X_1, X_2, X_3, and X_4 are denoted by the vector $x = (X_1, X_2, X_3, X_4)$ where X_1 represents direct *labour,* X_2 *is* indirect labour, X_3 *represents* material consumption and X_4 *represents* consumption of production services. The production process indicates that the consumption of each input depends on only the quantity of outputs Y_1, *and* Y_2 produced and in particular is independent of the level of consumption of the other inputs. That is, Xi = $f_i(Y_1, Y_2)$, for all i = 1,2,3,4 …….(2.1). In the opinion of Hossain and Karunakara (2004), the gross output determines the inclusion of raw materials as an input variable in the model might deplete the value of capital and labour in the production process that enhance growth of

the manufacturing company. The relationship between productivity, consumption and manufacturing sector performance in Nigeria was empirically investigated. The result showed that efficiency and productivity are significantly related to energy consumption price and supply in the Nigerian manufacturing sector which implied that energy plays significant role in ensuring that the impact of the manufacturing sector is achieved (Adenikinju & Alaba, 2000). The role of structural changes and transformation of manufacturing share in aggregate output firms was carried out by Elhiraika, (2008).The findings of the study revealed that rise in share of manufacturing firms has impact positively on GDP rate and reduce growth volatility. The impact of efficient inventory management on profitability of Ghana manufacturing sector was investigated, the research design was cross sectional showing data from 2004 to 2014. The study revealed that there is significant relationship between raw material inventory management and profit of the firm, which implied that efficient inventory management system could better the lot of the firm in terms of the profit to be realized (Kwadwo, 2016).

2.4 Scale Efficiency of the Manufacturing Sector in Nigeria

The scale efficiency is a measure used to determine inefficiency in the input-output process configuration during the time of manufacturing operations (Tafamel & Akrawah, 2015). The scale efficiency is used to investigate the efficient frontier under the assumption of variable returns-to-scale. The scale efficiency is a managerial tool used to organize the inputs in the production process to bring about performance. Thus, it is an index to capture managerial performance. Scale efficiency, allocative efficiency and technical efficiency are applied in the manufacturing process to determine the degree of economic efficiency of inputs (Worthington, 2001). Total economic efficiency is possible when the firm utilizes its resources in the right direction. That is optimal technical and scale efficiency. When the firm is operating at less than total economic efficiency, allocative and technical efficiency will arise. The nature of a given situation, the strength and mix elements are some of the approaches to determine efficiency strategy (Osuagwu, 2004). Productive efficiency is calculated at the lowest possible cost given a particular state of technology (Kumbhakar & Lovell, 2003). Efficiency ensures that scarce productive resources are used for the production of goods and services desirable by the consumer i.e allocative efficiency. When output is effectively distributed in a way that members of the society will not spend his/her resources anyhow given the prevailing level of income and market prices, is known as distributional efficiency. Scale economies may be technically inefficient when points on the technical production function appear on the scale anywhere than most scale efficient level while constant return to scale measures the different technical efficiency over many scales of production. Allocation of scarce productive resources

to achieve pre-determined goals and objectives is called efficiency (Hollingsworth & Parkin, 1998) as cited in (Bdour & Al-khoury 2008)

2.5 Technical Efficiency of the Manufacturing Sector in Nigeria

The manufacturing companies are vested with the production of a certain number of products, specified by a given design (Nor & Mohammed, 2014). In the technical development process, the solid goal is fashioned out, and the various means of production are duly calculated. Technical development is an interactive or always ever changing proceeding process (Ogundari, Kojo & Ajibefun, 2006). Dipak and Ata (2003) are of the opinion that the challenges facing the Nigerian manufacturing sector is the technological advancement given the international manufacturing market towards higher levels of consumption. Technical efficiency measurement is based on the assumption of effective production technology. Production technology is represented by isoquants and many functions such as profit, cost and production (Mokhtar, Alhabshi, & Abdullah, 2006). The importance of scale efficiency to firm cannot be underestimated because it helps to establish inefficiency and determine the input-output configuration defined in terms of size of the firm's operations. Scale efficiency is measured using efficiency frontiers with the assumption of variable return to scale. This helps to measure the managerial performance of the firm in terms of production of goods and services and input combination (Bdour & Al-khoury, 2008).

2.6 Allocative Efficiency of the Manufacturing Sector in Nigeria

Tafamel and Akrawah (2015) observed that, scale efficiency measure is used to determine the inefficiency in the input-output process configuration during the time of manufacturing operations. Technical efficiency measurement is based on the assumption of effective production technology. And as such, production technology is represented by isoquants and many functions such as profit, cost and production (Mokhtar, Alhabshi & Abdulahi (2006). Allocative efficiency as observed by Prateek (2019) is the level of output where the price of goods or services is equal to the marginal cost of production. In concise terms, it is the degree of equality between the marginal benefit and the marginal cost. The cost of producing one additional unit or items of goods is marginal cost and it is used to explain the optimal economics of scale. On the other hand, the greater enjoyment derives by creating one additional item, is the marginal benefit Loyce & Ishtiag (2018). One of the powerful means of evaluating manufacturing firms, performance is by accessing its efficiency when consumer pay a market price that reflect marginal cost of production, allocative efficiency had occurred therefore, for a manufacturing firm to be able to produce an output when marginal cost, MC equals price, such firms has efficiently allocate its resources Prateek (2019).

2.7 Empirical Reviews

Chu and Kaliappa (2010) carried out a study on trade liberalization and efficiency of the Vietnamese manufacturing firm. It was revealed that trade liberalization and human capital proxy by skilled workers had a significant positive influence on the manufacturing sector's efficiency. The study also showed that capital-labour ratio had a significant negative influence on the manufacturing sector's efficiency. Faruq and David (2010) investigated the technical efficiency of firms in Ghana using six (6) manufacturing industries for the period of 1991 to 2002. The empirical results from Data Envelopment Analysis (DEA) revealed that the manufacturing companies in Ghana were not technically efficient compare to manufacturing companies in other emerging countries. Similarly, Akpan, Ukoha, Onyenweaku and John (2012) carried out research study on the relationship between efficiency, macroeconomic variables and industrial policy in sugar industry in Nigeria using data from 1970 to 2010. Secondary data obtained from central banks, food industries and sugar farms. The result obtained indicated that efficiencies value was unstable and downward fluctuations at an average value of 50.80% *and 49.20% rate of excess technical efficiency. This also means that, official tariff rate on sugar input, real exchange rate capital-labour ratio sales growth and liberalization policy period influenced the sugar technical efficiency.* Saibu and Nwosu (2011) investigated the effect of monetary policy on the sectoral output in Nigeria from 1986 to 2008 using auto regression distributed lag model (ARDL) for the purpose of analysis. Their findings were that, manufacturing sector was not sensitive to any monetary policy variables. This implies that interest rate and exchange rate do not really influence output growth among manufacturing sector of the economy. Similarly, Akpan, Ukoha, Onyenweaku and John (2012) carried out research study on the relationship between efficiency, macroeconomic variables and industrial policy in sugar industry in Nigeria using data from 1970 to 2010. Secondary data obtained from central banks, food industries and sugar farms. The result obtained indicated that efficiencies value was unstable and downward fluctuations at an average value of 50.80% *and 49.20% rate of excess technical efficiency. This also means that, official tariff rate on sugar input, real exchange rate capital-labour ratio sales growth and liberalization policy period influenced the sugar technical efficiency.* Tafamel and Akrawah (2015) carried out an empirical investigation of the profitability and cost efficiency of oil and gas companies in Nigeria. They made use of nine (9) quoted oil and gas companies in Nigeria for two consecutive years 2012 to 2013 for the empirical analysis. The study adopted the data envelopment analysis to determine the efficiency of the sampled companies. The empirical results showed that Caverton Offshore Plc, Eternal oil and gas, Japaul oil, Mobil oil and Total oil were all efficient under scale efficiency while Oando oil was not efficient under constant return to scale. Orji, Anthony-Orji, Nchege and Okafor (2015) conducted a study *on manufacturing output and foreign direct investment in Nigeria. They employed a*

linear regression model for the data analysis. The results showed foreign direct investment and manufacturing sector output were negatively related. This, in other words, means that increased FDI inflows into critical sectors would bring about inputs and raw materials needed by the local industries. Osamwonyi and Imafidon (2016) investigated technical efficiency of activities of manufacturing firms on the Nigeria stock exchange in 2016. They adopted oriented DEA statistical technique for the study, which indicated that most manufacturing companies on the exchange are efficient under the variable return to scale with mean value of 85% and 76% efficiency scale. The findings of their result is that thirty one firms out of fifty eight are operating under variable returns to scale and the remaining twenty-seven companies are not operating under variable return to scale. Fadzim, Aziz, Mat and Maamor (2016) carried out a study on the determinants of technical efficiency among smallholder cocoa farmers in Malaysia. They adopted a survey research design through the distribution of structured questionnaires to 375 smallholder cocoa farmers. They found out from the empirical results that record keeping, level of knowledge and status of farmers affect the technical efficiency of the farmers negatively. This therefore implied that the low productivity was due to the continuous fall in percentage share of cocoa output.

3.0 METHODOLOGY

3.1 Research Design

This study used a longitudinal research design as it aims at studying events or groups over a period of time. This research design looked into the activities of the quoted companies in the manufacturing sector of the Nigerian Stock Exchange for the periods between 2011 and 2015. The choice is premised on the non controllability and manipulability of the independent variable.

Quoted firms listed on the Nigeria Stock Exchange is the population for the study and is made up of one-hundred and eighty-six (186) quoted firms whose shares are quoted on the floor of the Nigerian Stock Exchange. Each firm in the population must have completed its obligation in delivering annual report for five consecutive years (2011 to 2015). The sample size was based on the manufacturing companies in Nigerian Stock Exchange (NSE, 2015). Companies from hotel and tourism, banking, insurance, transportation, media and communication sectors are excluded from the sample population. The justification for excluding these companies was based on the fact that these companies are service-rendering companies, as well as conglomerate companies. Nineteen (19) manufacturing quoted companies were selected for the study.

3.2 Model Specification and Measurement of Variables

The study was subjected to two broad model categories. Model 1 focused on the input-output efficiency of capital and labour using DEA input-oriented CCR model and model 2 focused on the Leontief input-output model.

3.2.1 Model 1: DEA Input-Oriented Charnes, Cooper and Rhodes (CCR) Model

Charnes, Cooper and Rhodes developed data envelopment analysis in 1978. The data envelopment analysis was used to utilize linear programming techniques to extend further Farrell's (1957) single output/single input efficiency measure to multi-output/multi-input case. The central idea of data envelopment analysis is to optimize the ratio of inputs by solving for a group of weight that satisfy a system of linear equation (Rouse, Putterill & Ryan, 1997). This is shown below:

Maximize $\emptyset_i$

$\emptyset i \lambda_i$ ……(3.1)

Subject to:

$\emptyset i \lambda_i \ldots \sum \lambda_{ri} + S_{ri} = 0 \ldots\ldots\ldots\ldots\ldots\ldots(3.2)$

$r = 1 \ldots s$ output of manufacturing companies

$X_{ki \ldots} \sum \lambda_j X_{kj} - e_{ki} = \ldots\ldots\ldots\ldots\ldots(3.3)$

k = 1 … m input of manufacturing companies

$\lambda_j \geq 0, S_{ri} \geq 0, e_{ki} = 0 \ldots\ldots\ldots(3.4)$

i,j = 1…. N manufacturing companies in the sample

Where:

$\emptyset$ = proportional increase in outputs possible:

S_r = r-th output slack;

e_{ki} = k-th input slack;

λ_j = weight or intensity variable used to derive all possible linear combinations of the sample observations.

When the value of $\emptyset_{i,}$ in equation(3.1) is 1, λ_i and $\lambda_i = 0$ for $j \neq i$,

the i-th manufacturing company lies on the frontier and is technically efficient.

Furthermore, input and output slacks will always be zero for the efficient manufacturing companies. For the manufacturing Companies, $\emptyset_i > 1$, $\lambda_i = 0$, and $\lambda_j \neq 0$ for $j \neq I$, where j denotes the efficient manufacturing companies in the sample. Inefficient manufacturing companies may also have some positive output or/and input slacks. The output based technical efficiency index of the i-th the companies (Te_j) can be computed as follows:

$$Te_j = \frac{1}{\emptyset_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.5)$$

The frontier production of the r-th output of i-th manufacturing companies can be computed as follows:

$$X_{ki} = \sum_{j=1}^{n} y_{rj} = \Sigma \lambda_{rj} y_{ri} = \emptyset_i y_{ri} + S_{ri} \quad \ldots\ldots(3.6)$$

Equation (3.6) showed that the projected output consists of two components, one representing the proportional increase in all output ($\emptyset_i y_{ri}$) and the other accounting for the non-proportional increase or output slack (S_{ri}). Besides estimating the maximum output from fixed inputs, the output-oriented DEA in equation (3.1) also estimated the input slacks (excess inputs) that needed to be conserved for an inefficient manufacturing company to be fully efficient. Mathematically, the projected amount of the k-th resource of the i-th manufacturing companies (x_{ki}) can be expressed as follows:

$$X_{ki} \quad \sum_{j=1}^{n} \lambda X_{kj = Xri} - e_{ki} \quad \ldots\ldots\ldots\ldots(3.7)$$

The DEA model for manufacturing companies is given in equation (3.1) relates to constant returns to scale. According to Banker, Charnes and Cooper (1984: 34) 'the corresponding model under variable returns to the scale (VRS) can be obtained by imposing an additional constraint, $\Sigma_{j=1} \lambda_j = 1$ on equation (3.3)'. The term 'overall' is the efficiency score obtained from CRS model (TE_{CRS}) while VRS model is 'pure' technical efficiency ($TE_{VRS)}$. Consequently, in general, some companies will show a poorer performance under the CRS model than in the VRS model (i.e., $TE_{VRS} \geq TE_{CRS}$ $\emptyset_{CRS} \geq \emptyset_{VRS}$). This relationship is often used to obtain a measure of scale efficiency (SE) as follows:

$$SE = \frac{Te_{CRS}}{Te_{VRS}} = \frac{\emptyset_{VRS}}{\emptyset_{CRS}} \quad \text{.....(3.8)}$$

Where,
SE = 1 indicates scale efficiency and SE < 1 indicates output-based scale inefficiency. Scale inefficiency is due to the presence of either increasing (IRS) or decreasing returns to scale (DRS) which can be determined by solving a non-increasing returns to scale (NIRS) DEA model which is obtained by substituting the VRS constraint $\Sigma_{j=1} \lambda_j = 1$ with $\Sigma_{j=1} \lambda_j \leq 1$.

Let $\emptyset_{NIRS}$ represents the proportional increase in all outputs under the NIRS DEA model. For scale inefficient observations, $\emptyset_{CRS} = \emptyset_{NIRS}$ indicates inefficiently small-scale or operation in the region of increasing returns to scale and $\emptyset_{CRS} = \emptyset_{NIRS}$ indicates inefficiency large scale or decreasing returns to scale (Fare, Grosskopf & Lovell, 1994).

3.2.2 Model 2: Leontief Input-Output Model

Wassily Leontief developed input-output model to examine the inflows and outflows of goods and services in a tabular form. This model investigated the inputs, i.e purchase and output (sales), across the different sectors of an economy for a given period. The production sector utilizes outputs of the sector and in other production activities and subsequently the final consumers (such as government, households and nations)

In a table format by Leontief, Xi is the gross output of the ith sector, Xij represents the amount of the ith sector's output used by the jth sector to produce its output, and Xj is the final consumers' use of the ith sector's output. The inputs are, labour, W, and capital, R is described in the bottom rows of the table. Wi, represents the use of labour in the production of ith product, W is the use of labour by final consumers, Ri is the use of capital in the production of other goods, and R is the final demand for capital.

The rows of the table describe the total amount of a product or primary input to all uses, both intermediate and final. For example, suppose sector 1 represents food products, then the first row tells us that, out of a gross output of X.tons of food products, an amount X… is used in the production of food products themselves, an amount of X….must be delivered to sector 2, X.i. tons are delivered to sector i, X.n to sector n, and X. tons are consumed by final end users of food products. The columns of the table describe the input

requirements to produce the gross output totals. Thus, producing the X.tons of food products requires X…tons of food products, along with X…units of output from sector 2 (steel, perhaps), X.i from sector i, Xn. from sector n, W. hours of labour, and R. naira of capital.

The model overall considers the n sectors or industries, two primary factors of production (capital and labour), and initially four types of final demand (personal consumption expenditures, C; investment expenditures, I; government purchases of goods and services, G; and exports, E).

For example, the total demand for the output of sector i, that is, the allocation of the output of the ith sector can be written as

$$Xij = \sum_{j=1}^{n} Xij + Fi \quad i = 1*n \quad \ldots\ldots\ldots\ldots (3.9)$$

$$\ldots\ldots\ldots\ldots (3.9)$$

Where;

$\sum_{j=1}^{n} Xij$ = the total inter-industry demand for the output of sector i, or sales by sector i to the n sectors and Fi = the total final demand for the output of sector i.

$$Fi = Ci + Ii + Gi + Ei \ldots\ldots\ldots\ldots\ldots (3.10)$$

3.3 Method of Data Analysis

The study used Data Envelopment Analysis (DEA) application to explain the Leontief input-output model. The performance efficiency scores of selected manufacturing companies in Nigeria were computed by the DEA and the DEA Frontier Software.

4.0 DATA PRESENTATION AND ANALYSIS OF RESULTS

In line with the discussion above, the study presented the DEA analysis for CRS, VRS and SCALE efficiency for the Leontief input-output relationship. Secondly, the study provided the descriptive statistics and correlation matrix for input-output variables. The manufacturing performance efficiency scores that were generated from the DEA methodology were based on the three efficiency measures; (1) DEA Overall technical efficiency score (CRS): This was obtained when the study assumed a constant return to scale for all the manufacturing companies in the sample. This implies that an increase input by 1% would lead to a corresponding 1% increase in its output. This did not consider however the company's management skills in converting small inputs to large outputs; (2) DEA pure technical efficiency score (VRS): This was obtained when the study assumed a variable return to scale for all the sampled manufacturing companies. This implied increase in the manufacturing companies input by 1% would lead to more than 1% increase in its output; (3) Scale efficiency score (SCALE): This is the ratio of constant return to scale to variable return to scale (CRSE/VRSE). This focused on measuring the extent to which management accounting skill was relevant in converting small inputs to large outputs and all these measures. In all three measures of the input-output relationship (efficiency) the rule is that a company is classified as efficient when it has a score of "1" and inefficient when it has a score less than "1".

4.1 CRS Efficiency Performance Measurement

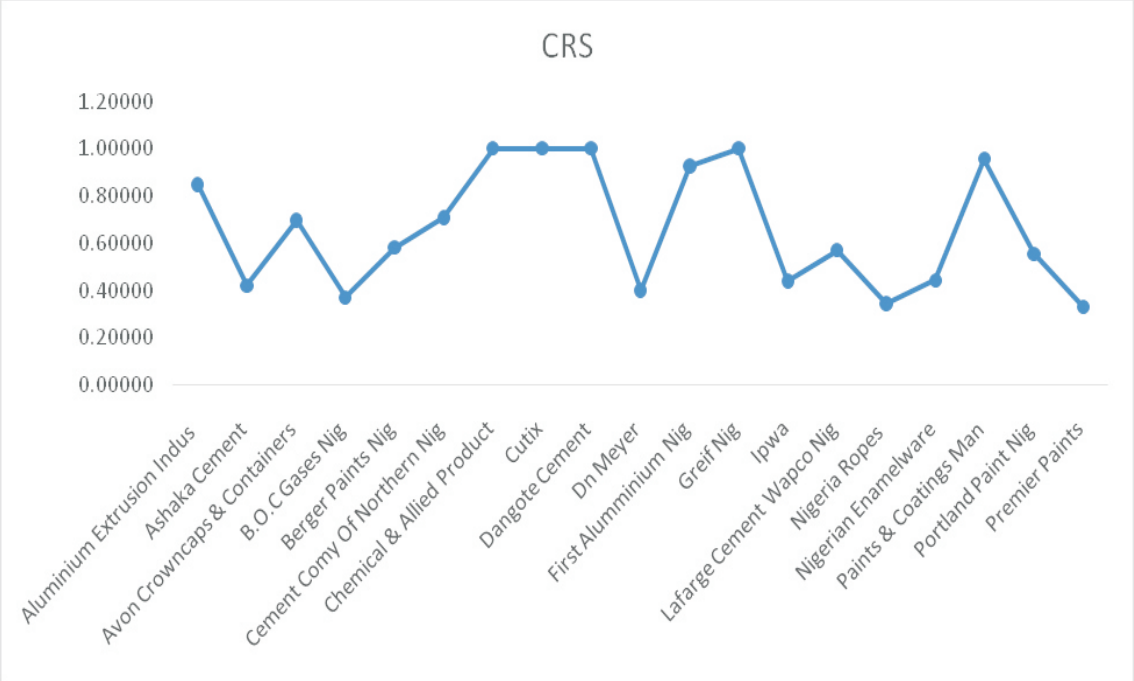
The DEA overall technical efficiency score (CRS) was obtained when the study assumed a constant return to scale for the manufacturing companies. This implied that an increase in input by 1% would lead to a 1% increase in its output. This did not consider management skills in converting small inputs to large outputs. This study was evaluated for a five year (2011-2015) efficiency score of 19 manufacturing companies in Nigeria. The results obtained are presented as follows: The overall technical efficiency score (i.e. technical efficiency relative to the CRS DEA model) for each of the sampled companies is presented in Table1. The CRS DEA model was based on the assumption of constant return to scale for the companies. (See Appendix I for the full CRS efficiency result).

Table 1: 2011-2015 Technical efficiency scores based on CRS DEA model

DMU No.	DMU Name	Input-Oriented CRS Efficiency
	DMU	0.00000
1	Aluminium Extrusion Indus	0.84707
2	Ashaka Cement	0.42019
3	Avon Crowncaps & Containers	0.69686
4	B.O.C Gases Nig	0.36878
5	Berger Paints Nig	0.58107
6	Cement Com Of Northern Nig	0.70702
7	Chemical & Allied Product	1.00000
8	Cutix	1.00000
9	Dangote Cement	1.00000
10	Dn Meyer	0.39955
11	First Alumminium Nig	0.92610
12	Greif Nig	1.00000
13	Ipwa	0.44023
14	Lafarge Cement Wapco Nig	0.56920
15	Nigeria Ropes	0.34547
16	Nigerian Enamelware	0.44181
17	Paints & Coatings Man	0.95623
18	Portland Paint Nig	0.55527
19	**Premier Paints**	0.33156

Source: Author's Computation (2016)

In Table 1, the study found out that on the basis of the five years the constant return to scale (CRS) technical efficiency scores of the 19 manufacturing companies selected, only Chemical and Allied Product (CAP), Cutix, Dangote Cement and Greif were efficient under constant return to scale (CRS) after taking five years average inputs and outputs to sustain its efficiency within the period. This implied that these four listed companies are more efficient while the other 15 (fifteen) were not efficient under the theory of constant return to scale in the period under investigation. The efficiency analysis result implied that the four companies have 100% efficiency scale while others have less than 100%. The graph below represents further explanation of the result:



VRS DEA Results

The DEA models were involved in examining the Leontief input-output relationship (efficiency) of manufacturing companies in Nigeria using DEA Frontier software. Table 4.2.2. indicated the overall technical efficiency of the manufacturing process. The variable return to scale (VRS) DEA model was based on the assumption of variable return to scale. (See appendix I for the VRS efficiency result).

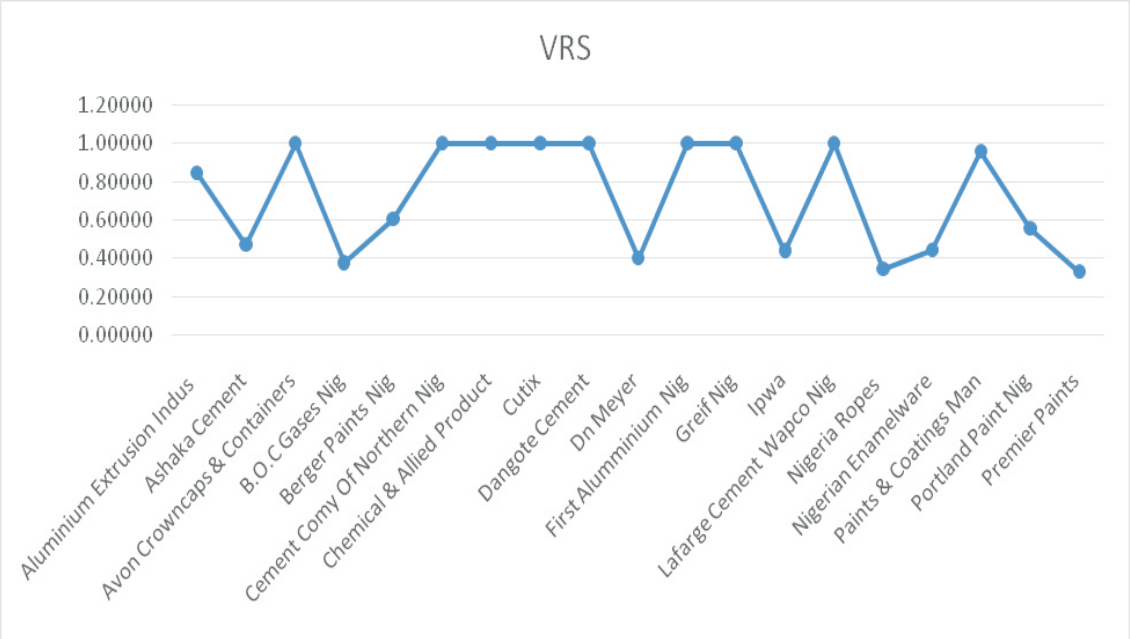
Table 2: 2011-2015 Technical efficiency scores based on VRS DEA model

DMU No.	*DMU Name*	*Input-Oriented VRS Efficiency*
	DMU	0.00000
1	Aluminium Extrusion Indus	0.84707
2	Ashaka Cement	0.47066
3	Avon Crowncaps & Containers	1.00000
4	B.O.C Gases Nig	0.37743
5	Berger Paints Nig	0.60527
6	Cement Com Of Northern Nig	1.00000
7	Chemical & Allied Product	1.00000
8	Cutix	1.00000
9	Dangote Cement	1.00000
10	Dn Meyer	0.39955
11	First Alumminium Nig	1.00000
12	Greif Nig	1.00000
13	Ipwa	0.44023
14	Lafarge Cement Wapco Nig	1.00000
15	Nigeria Ropes	0.34547
16	Nigerian Enamelware	0.44265
17	Paints & Coatings Man	0.95683
18	Portland Paint Nig	0.55634
19	Premier Paints	0.33156

Source: Author's Computation (2016)

Table 2, shows that the variable return to scale technical efficiency scores of the sampled manufacturing companies for the period of 2011 to 2015 has Avon Crowncap and Containers, Cement Company of Northern Nigeria, Chemical and Allied Product, Cutix, Dangote Cement, First Aluminum Nigeria, Greif and Lafarge cement passing the efficiency test for the period. These eight (8) quoted companies were effective in managing their capital and labour inputs to produce outputs in an efficient manner. This showed that only eight (8) companies were efficient under variable return to scale while the remaining eleven (11) companies were not efficient under variable return to scale. This in other words means that the 8

quoted companies out of the 19 quoted companies had a variable return to scale efficiency scores of 100% while 11 quoted companies had a variable return to scale efficiency score of less than 100%. The result was also presented graphically as shown below;



Scale DEA Results

The overall technical efficiency score (i.e. technical efficiency relative to the scale efficiency DEA model) for each of the 19 manufacturing companies is presented in Table 3. The scale efficiency DEA model was tougher efficiency test which was based on constant returns to scale and variable returns to scale.

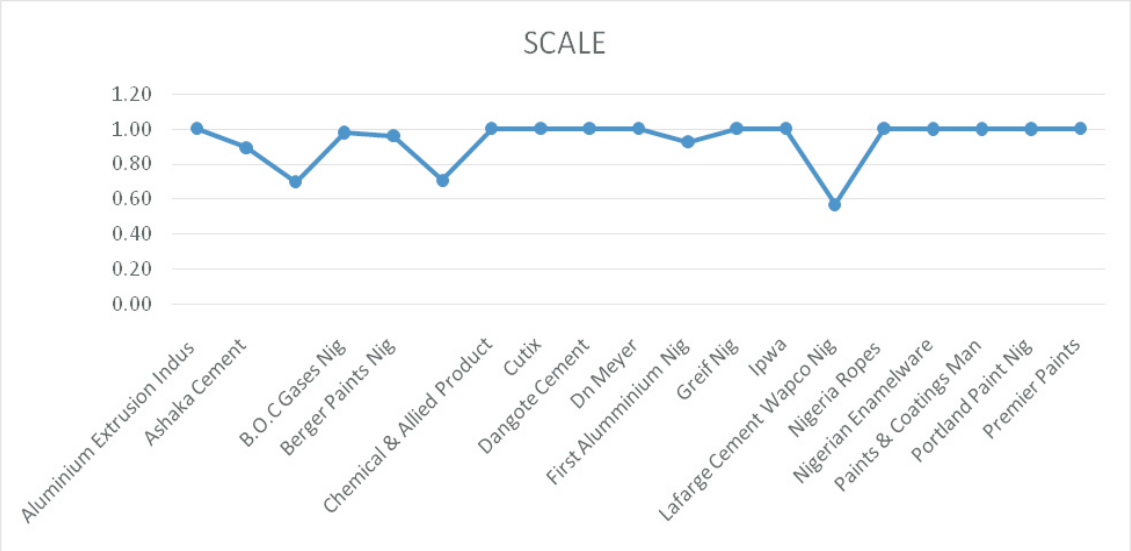
Table 3: The Scale Efficiency DEA

DMU	SCALE
Aluminium Extrusion Indus	1.00
Ashaka Cement	0.89
Avon Crowncaps & Containers	0.70
B.O.C Gases Nig	0.98
Berger Paints Nig	0.96
Cement Com Of Northern Nig	0.71
Chemical & Allied Product	1.00

Cutix	1.00
Dangote Cement	1.00
Dn Meyer	1.00
First Alumminium Nig	0.93
Greif Nig	1.00
Ipwa	1.00
Lafarge Cement Wapco Nig	0.57
Nigeria Ropes	1.00
Nigerian Enamelware	1.00
Paints & Coatings Man	1.00
Portland Paint Nig	1.00
Premier Paints	1.00

Source: Author's Computation (2016)

Table 3, reveals that Aluminium Extrusion Industries, Chemical and Allied Product, Cutix, Dangote Cement, Dn Meyer, Greif Nigeria, Ipwa, Nigeria Ropes, Nigerian Enamelware, Paints and Coatings Manufacturers, Portland Paints and Premier Paints are scale efficient among the 19 quoted manufacturing companies sampled for the period while the remaining seven (7) companies are not scale efficient. This means that twelve (12) manufacturing companies among the sampled companies show consistent sign of strength. Its scale efficiency score showed that apart from being strong in utilizing capital and labour more efficiently in the manufacturing sector, with good managerial skills the quoted companies had scale efficiency scores of 100%. Thus illustrated graphically as shown below;



Overall DEA Results

Above all, the overall result for technical and scale efficiency score for the 19 listed companies examined between 2011 and 2015 are in table 4.

Table 4: Technical and Scale Efficiency Scores of Quoted Manufacturing Companies in Nigeria (2011-2015)

S/N	DMU	CRS	VRS	SCALE	REMARK
1	Aluminium Extrusion Indus	0.84707	0.84707	1.00	CRS
2	Ashaka Cement	0.42019	0.47066	0.89	IRS
3	Avon Crowncaps & Containers	0.69686	1.00000	0.70	DRS
4	B.O.C Gases Nig	0.36878	0.37743	0.98	IRS
5	Berger Paints Nig	0.58107	0.60527	0.96	IRS
6	Cement Com Of Northern Nig	0.70702	1.00000	0.71	DRS
7	Chemical & Allied Product	1.00000	1.00000	1.00	CRS
8	Cutix	1.00000	1.00000	1.00	CRS
9	Dangote Cement	1.00000	1.00000	1.00	CRS
10	Dn Meyer	0.39955	0.39955	1.00	CRS
11	First Alumminium Nig	0.92610	1.00000	0.93	DRS
12	Greif Nig	1.00000	1.00000	1.00	CRS
13	Ipwa	0.44023	0.44023	1.00	CRS
14	Lafarge Cement Wapco Nig	0.56920	1.00000	0.57	DRS
15	Nigeria Ropes	0.34547	0.34547	1.00	CRS
16	Nigerian Enamelware	0.44181	0.44265	1.00	CRS
17	Paints & Coatings Man	0.95623	0.95683	1.00	CRS
18	Portland Paint Nig	0.55527	0.55634	1.00	CRS
19	Premier Paints	0.33156	0.33156	1.00	CRS
	Mean	0.66244	0.72490	0.93287	

Source: Author's Computation (2016)

Table 4 has the scores for the technical and efficiency scale of listed companies on the Nigeria stock exchange**.** On the overall, the sample mean was 72% for the listed firms and 93% efficiency scale, which indicated that most manufacturing firms are operating under variable returns and scale efficiency. The result from the Table further confirms that eight listed companies out of the examined companies are technically efficient while eleven are technically inefficient. This is due to the fact any score below 100% is technically efficient under the variable return to scale

assumptions. It was obvious from the Table that Premier paints with 33% and B.O.C Gases with (98%) efficiency score are technically inefficient and they required 67% and 2% respectively to scale down to become more technically efficient and produce the same level of output because of decreasing return to scale. Conclusively, 63% of the listed firms had most productive scale size while 37% are inefficient. Based on the results interdependence exists among the sampled companies and thus, nineteen companies operated on the production possibility frontiers while the other twelve firms operated on the constant return to scale. There were exceptions for Aluminum Extrusion Industries, Dn Meyer, Ipwa, Nigerian Enemelware, Nigerian Ropes, Paints and Coatings Manufacturers, Portland Paints and Premier Paints exhibited constant return to scale despite the fact of being technically inefficient. This showed that they operated at their most productive scale size while the remaining four quoted companies exhibited decreasing return to scale, which means that the input factors were over-employed despite the fact that they were efficient. Furthermore, the result revealed that four firms sampled were operating on the decreasing return to scale (DRS) which implied that changing all the inputs by the same rate brings about a smaller change in output, while other three were operating on increasing return to scale (IRS) which implied that changing all inputs by the same rate brings about the same results in outputs. The implication is that the firms must increase the quantity of their factor inputs used in production. Inefficiency in other firms can be attributed to factor inputs not being enough thus the need to introduce factor inputs becomes necessary. The solution to the inefficiency is for firms to carry out activities in the most productive scale on the decreasing return to scale while developing strategy to operate on the increasing return to scale is increase input consumption and expansion of output to achieve productive scale size.

4.2 Discussion of Findings

The analysis of data shows that the mean value of the sampled listed companies is 72%, which indicates technical efficiency under variable return to scale and 93% value for scale. The value further explained that listed firms sampled on the Stock Exchange are relatively efficient and there is level of interdependence among these companies in Nigeria. The result of the study is in consonance with the findings of Osamwonyi and Imafidon (2016) that listed companies in Nigeria are efficient under variable return to scale, with the mean score of 85% and scale efficiency mean score of 76%. The study therefore rejects the null hypothesis, that there is no interdependence among industries in the Nigerian manufacturing sector. The empirical result indicates that increase in the inputs is expected to also increase the level of outputs. This means that there is a relationship between inputs and outputs. The result of this study is in consonance with the finding of Kwadwo (2016) that there is a significant positive relationship between raw materials inventory management and profitability of manufacturing firms. The study therefore rejects the null hypothesis that the input-

output relationship of the manufacturing sector in Nigeria is not significantly related. The result reveals that Chemical and Allied Product (CAP), Cutix, Dangote Cement and Greif were efficient under constant return to scale (CRS) after taking five years average inputs and outputs to sustain its efficiency within the period. The result of the study is in consonance with the findings of Osamwonyi and Imafidon (2016) that the efficient level of these companies with mean values of 85% and scale efficiency of 76% indicates that these sampled firms are efficient under variable return to scale. The thirty-one companies out of the fifty-eight companies selected for the study are operating under variable return to scale and the remaining twenty-seven companies are not operating under variable return to scale. The findings of Adewuyi (2006) supported the findings that the nominal protection rate and import penetration ratio have a significant positive influence on the technical efficiency of the manufacturing sector. The findings of Faruq and David (2010) in Ghana are contrary to the finding that manufacturing companies in Ghana were not technically efficient and less significant to other manufacturing companies in other emerging countries. The study therefore rejects the null hypothesis that the manufacturing sector in Nigeria is not technically efficient. The empirical result shows that Aluminium Extrusion Industries, Chemical and Allied Product, Cutix, Dangote Cement, Dn Meyer, Greif Nigeria, Ipwa, Nigeria Ropes, Nigerian Enamelware, Paints and Coatings Manufacturers, Portland Paints and Premier Paints are scale efficient among the 19 manufacturing companies sampled. While the remaining seven (7) companies, are not scale efficient. The study is consistent with the findings of Osamwonyi and Imafidon (2016) that manufacturing quoted companies in Nigeria selected for the study are operating under variable return to scale. The study therefore rejects the null hypothesis that the manufacturing sector in Nigeria is not scale efficient.

5.0 CONCLUSION AND RECOMMENDATIONS

The study analysed the Leontief input-output relationship of manufacturing companies in Nigeria. The Nigeria manufacturing sector is characterized by large number of firms producing identical products based on the production function. The input-output analysis is based on efficiency which is the relationship between output of goods and services and the input resources that is, human and capital resources available in the production processes. The empirical results showed the mean of the quoted company technical efficiency under variable return to scale score of 72% and a scale efficiency score of 93%. This shows that the Nigerian quoted manufacturing companies are relatively efficient under variable return to scale and scale efficiency which signify that there is interdependence among the quoted manufacturing companies in Nigeria. The empirical result showed that increase in the inputs is expected to also increase the level of outputs. This means that there is a relationship between inputs and outputs, Chemical and Allied Product (CAP), Cutix, Dangote Cement and Greif were

efficient under constant return to scale (CRS) after taking five years average inputs and outputs to sustain its efficiency within the period. Aluminium Extrusion Industries, Chemical and Allied Product, Cutix, Dangote Cement, Dn Meyer, Greif Nigeria, Ipwa, Nigeria Ropes, Nigerian Enamelware, Paints and Coatings Manufacturers, Portland Paints and Premier Paints are scale efficient among the 19 manufacturing companies sampled while the remaining seven (7) companies are not scale efficient. The correlation matrix result shows that the inputs and outputs in our study are near perfect correlated. This is expected since increase in the inputs is expected to also increase the level of out puts. The empirical result from this study is useful for policy formulation, implementation and recommendation. From the empirical findings, we recommend that:

(i) Management and concerned authorities of the manufacturing companies in Nigeria should ensure that the manufacturing sector is technically efficient. This could be achieved by using adequate input in terms of factors of production so as to maximize output

(ii) Quoted manufacturing companies should increase the quantity of factors input employment so as to enjoy technical and scale productive efficiency.

(iii) The efficient listed companies should merge with the inefficient quoted manufacturing companies in order to enjoy economies of large- scale production in the same manufacturing sector in Nigeria.

(iv) The study also recommends that the government should provide an enabling platform for the inefficient manufacturing companies by formulating policies favourable in term of tax relief and holiday for productive efficiency of the sector. Strict control measures should be put in place by the government to check and reduce smuggling activities and excess importation of input materials from foreign countries. This is to encourage the use of locally source materials for manufacturing.

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