TECHNICAL AND ECONOMIC EFFICIENCY OF CHEMICAL AND PHARMACEUTICAL INDUSTRY IN NIGERIA

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ABSTRACT
In this study, the technical efficiency of the Chemical and Pharmaceutical manufacturing firms in Nigeria was estimated by using a stochastic frontier production function, incorporating the technical inefficiency effect model. The translog frontier model was found to be an adequate representation of the data, given the specification of the corresponding Cobb Douglas production function. The technical inefficiency effects were found present and contained a significant random element. Results from the translog regression showed a sigma square (σ^2) of 1.975 which was statistically significant at 1 percent. The technical efficiency scores in the Chemical and Pharmaceuticals sector ranged from 0.012 to 0.82 with a mean of 0.488. The individual impacts of some of the variables in the inefficiency effect model were significant, also the combined influence of all the five variables was significant in reducing the inefficiency of the Chemical and Pharmaceutical manufacturing firms in Nigeria. The results also indicated that the industries were operating at increasing returns to scale. Amongst others, utilisation of enhanced inputs and improved technology by manufacturing firms was recommended, to enable the firms to attain the optimal production frontier.

Keywords: technical efficiency, translog stochastic frontier inefficiency model, manufacturing industry, Nigeria
JEL Classification: L65, D24, C6

1. INTRODUCTION
The global pharmaceutical industry faces various challenges wherein it must create a low growth in the industrial environment with environmental changes World Health Organization, {2017). Medicine development directly contributes to human life and health, and it involves a high level of expertise in biology and biochemistry. Medicines cannot be commercialized until they are approved by the Food and Drug Administration (FDA) to demonstrate a high level of effectiveness and safety under very stringent standards. During this process, astronomical costs are incurred and R&D costs can only be recovered if the approved medicines are patented and sold exclusively. On the other hand, the cost of manufacturing an approved drug is relatively inexpensive National Library of Medicine (2017).
Providing adequate health care to their populations remains a major challenge for governments in Africa. Unsatisfactory and inadequate access to essential drugs and other healthcare commodities is a key limitation that impacts people's health in most developing countries in which Nigeria is not an exception. Adequate access to drugs is dependent on both the affordability and quality of the products United Nations Industrial Development (2017).
The pharmaceutical sector in Nigeria is a complex one, involving many different stakeholders and players (such as the manufacturers, national regulators, wholesalers and others). It means that there is a need for these stakeholders to put in additional effort to create an enabling environment to exploit the full potential of the sector. The Pharmaceutical Manufacturers Group of the Manufacturers

Association of Nigeria (PMG-MAN, 2010) asserted that the Nigerian pharmaceutical sector has the potential to be a leader in production UNIDO, 2017.

Most of Nigeria's health indicators are poor and it will be impossible for the country to meet most of the targets for the Sustainable Development Goals (SDGs) by 2030. The challenges facing the health sector include inadequate and inefficient production, weak health infrastructure, inefficient distribution of the health workforce, capacity underutilization and poor coordination among key players Obinna et al (2019).

Chemicals have become part of our lives to support many of our daily activities, preventing and controlling diseases, increasing agricultural productivity, and so on. Chemicals used as synthetic drugs being at the core of modern industrial and production systems, the risk of accidents involving chemicals has attained a very serious concern for hazard management within the government, corporate sector, and the community at large World Health Organization (2015). Major chemical (industrial) hazards are low in frequency but are significant in terms of potential loss of lives, injuries, environmental impacts, property damage, and socioeconomic implications. The frequency and severity of chemical hazards have increased in recent years due to the rapid development of the largest chemical industries production and formulation, petrochemicals, pharmaceuticals, agrochemicals, industrial chemicals, and hazardous chemicals - oil deposits, exploration/extraction and reclamation sites, and so on. Increasing the size of plants, deposits, and bearers, especially in densely populated areas, represented the greatest risk and vulnerability to these dangers Gupta et al (2017).

The industry is also identified with environmental pollution which is becoming a global threat to ecosystems and human lives Maghear (2018). This is evident in the detection of pharmaceutical wastes in surface water, sewage effluents, groundwater, drinking water, manure, soil, and other environmental matrices globally Buckley and Gostin (2020), Mudgal et al (2013). Consequent to this pollution, evidence has shown significant growth in Antimicrobial Resistance (AMR) recognised as one of the biggest global public health concerns facing humanity Folk (2019), Bruni (2016).

The World Health Organisation (WHO) rated Nigeria's health sector 163rd out of 191 members (WHO, 2020). The poor rating of the sector is due to a lack of standard equipment for the production and storage of pharmaceuticals. Similarly, the 2018 Health access quality (HAQ) index, which measures the quality and accessibility of healthcare based on 32 causes of death which is preventable with effective medical care, ranked Nigeria 187 out of 195 countries, beneath Egypt (64th), Kenya (112th) South-Africa (119th) and Rwanda (173rd).

Economic efficiency aims to measure the relationship between an output and an input, between a product and resources to put it into effect (Parra and Javier 2011). A system is efficient when it maximizes the desired outputs given available inputs (Farrell 1957).

In the received literature on the measurement of technical efficiency, two different methods are commonly used to estimate frontiers: non-parametric mathematical programming (the data envelopment analysis) and econometric modelling. In the data envelopment analysis (DEA), data is exploited to construct a non-parametric frontier. According to Greene (2008), the DEA produces a piecewise linear, quasi-convex hull around the data points in the input space. The observed best practice, thus, becomes a production frontier. As technical efficiency requires production on the frontier, the DEA calculates efficiency by comparing each producer with the best practising producer. In econometric modelling, either deterministic or stochastic frontier models are used. In deterministic frontier models, all deviations from the production frontier are treated as inefficiency (Aigner and Chu, 1968; Afriat, 1972; and Richmond, 1974).

Following Battese and Corra (1977), stochastic frontier models have been used vastly, especially for the efficiency analysis of many different sectors (e.g., agriculture, banking, and hospitals). Although earlier stochastic frontier models were designed for and applied to cross-section data, Pitt and Lee (1981), Cornwell et al. (1990), Kumbhakar (1990), and Kumbhakar et al. (1991) developed and applied models that are compatible with panel data. In particular, using panel data improves degrees of freedom, and makes it possible to scrutinize the changes in technical efficiency over time (Coelli et al., 2005: 275). It is equally crucial to delineate the factors affecting technical inefficiency, which is not an easy task.

Disappointingly, reviewed empirical studies (Adamu Usman Musa(2021), Audu Bello et al (2021), Dominic Iortyer and Martins Onuh(2022), Ogungbenle Sola (2021).and Usio Uchechi Taiga and Ilemona Adofu) have been centred mainly impact of manufacturing on economic growth and development. The growth of the Nigerian Pharmaceutical industry has been featured in few empirical studies, but to the best of our knowledge, a comprehensive work on the technical efficiency of the industry in a multivariate framework has not been carried out. One of the works in this area is that of Efayena O. Obukohwo et al (2018). Their emphasis, however, was on the efficiency in the Pharmaceutical Sector in Nigeria using Data Envelopment Analysis.

This study aims to fill this gap by analyzing empirically, the technical and economic efficiency of the Pharmaceutical sector in Nigeria using the parametric Stochastic Frontier Analysis (SFA) for firm-level panel data of fifteen from 2000-2019. The specific objectives are:

1. To examine the levels of efficiency of the chemical and pharmaceutical firms in Nigeria and discuss the determinants of efficiency.
2. To estimate the technical inefficiency of Nigeria's chemical and pharmaceutical firms from 1999 to 2019.

This study uses data at the firm level from 2010-2019 using the Stochastic Frontier Analysis (SFA) approach involving two analyses. The first analysis will determine the level of technical efficiency among selected firms. The second analysis is to determine the determinant factors of technical inefficiency of the Chemical and Pharmaceutical industry in Nigeria. The second part of this article discusses the relevant theoretical and empirical literature. Section 3introduces the research methodology, data sources, and model specifications. While in section 4 the empirical results and the last part provides the conclusion and policy implications of the study.

2. LITERATURE REVIEW

2.1 CONCEPTUAL LITERATURE

Since Farrell's original work several frontier efficiency models have been developed based. They can be divided into two main categories namely parametric and non-parametric. Non-parametric methods involve the use of linear programming and do not require any functional form to be imposed on the data. Parametric frontiers models on the other hand are econometric estimates and use specific functional forms such as Cobb-Douglas which are then imposed on data. Another important classification was that of deterministic and stochastic frontiers models. Deterministic models assume that all deviation away from the frontier is due to inefficiency whereas stochastic frontiers account for measurement errors and exogenous random shocks which are beyond the control of the firm. These models have then been later extended to incorporate panel data (Coelli et al. 2005).

The author uses stochastic methods because for panel data, one would be expected to run into problems such as measurement errors and missing values. Moreover, random shocks such as exchange rate volatility, interest instability, etc. can also have a significant effect on efficiency. This method also has the advantage that it allows statistical inference and one can run hypothesis tests regarding the extent of inefficiency. Depending on what the research question is, one can opt from among the score of models which look at both technical change and efficiency, time-varying and time-invariant technical efficiencies.

The advantages of this approach are that hypotheses can be tested with statistical rigour and that relationships between input and output follow known functional forms. SFA enables the simultaneous estimation of technical efficiency and a technical inefficiency effects model (Coelli et al. 2005).

However, like every other econometric method, this approach also has its drawbacks such as compliance with regularity conditions and economic theory.

2.2THEORETICAL LITERATURE

The study is based on the following theories; Production efficiency theory, according to this theory developed by Aigner, & Chu (1968), the production efficiency theory that analyze differences in production technology to improve economic efficiency, especially labor productivity. The stochastic frontier model was originally developed by Aigner, Lovell and Schmidt (1977). Typically, the production or cost model is based on a Cobb –Douglas function: Neoclassical economics assume that producers in an economy always operate efficiently, however in real terms; producers are not always fully efficient. However, even though the concept of production efficiency is central in production performance, its estimation has been proved to be rather complex, with relevant literature providing a range of different methodologies and approaches (Lovell, 1993), with one of the major approaches to be the 'stochastic frontier analysis'. Stochastic frontier approach has found wide acceptance within the production economics literature, because of their consistency with theory, versatility and relative ease of estimation.

2.2 EMPIRICAL LITERATURE REVIEW

Efficiency is the effectiveness of using inputs to produce outputs. It is mainly influenced by production techniques, technological innovation, management skills and labour skills. The optimum efficiency can be generated and influenced by efficient input factors such as the quality of workers, while technical efficiency (TE) illustrates the ability of firms to produce maximum output when given a set of inputs (Farrell, 1957). Long-term efficiency can contribute to the growth of Overall Factor Productivity (TFP) (Ismail and Sulaiman, 2007). Productivity is the most important aspect at every stage of economic development planning policy in Nigeria.

Technical efficiency (TE), illustrates the ability of firms to produce the maximum output when given a set of inputs (Farrell, 1957Fahmy-Abdullah et al., 2018 Ogunbadejo et al 2022). Porcelli, (2009) asserted that the level of TE is equal to one and if the score is less than one, it indicates technical inefficiency.

A study on the determinant of TE is very important in the production theory (Fahmy-Abdullah et al., 2017). Long-term efficiency can determine the economic growth of a country (Fahmy-Abdullah et al., 2017) and contributes to productivity growth.

Ugbam and Okoro (2017) asserted that larger firms are more efficient in the pharmaceutical industry in Nigeria. This implies that smaller firms faced with stiff competition from rival firms will eventually wind up (Olugbenga, 2010).

Also, Fahmy-Abdullah et al. (2017) showed that the inefficiencies in determining wage rates and information and communication technology spending affect firms' technical competence.

It is equally crucial to delineate the factors affecting technical inefficiency, which is not an easy task. Pittand Lee (1981), and Kalirajan (1981) are the two pioneering studies estimating inefficiency effects. There are different approaches to estimating the factors affecting inefficiency. Using cross-sectional data at the firm level, Reifschneider and Stevenson (1991), Kumbhakar et al. (1991), and Huang and Liu (1994) estimate stochastic frontier models and the factors affecting inefficiency, simultaneously, under appropriate distributional assumptions. In contrast, Battese and Coelli (1995) estimate a stochastic frontier production function by using firm-level panel data where non-negative inefficiency effects have a truncated normal distribution with constant variance.

By using a translog production function and a stochastic frontier model with inefficiency effects, Ogunbadejo et al. (2022) study the technical efficiency of the 15 subsectors of the manufacturing industry in Nigeria from 1999-2019. The result reveals an estimated mean technical efficiency score of 0.52, implying that the sample manufacturing firms are operating 48% below the production frontier.

Also, they find a negative relationship between average firm sizes from technical inefficiency, and significant show that industries with a bigger share of output in total manufacturing output are more efficient.

3. METHODOLOGY

3.1 The Stochastic Frontier Analysis (SFA)

Stochastic frontier analysis (SFA) is a technique used for estimating a production frontier and predicting the maximum possible firm output. (Coelli 1996a, 1996b;).SFA is a parametric approach, where the form of the production function is assumed to be known or estimated statistically. SFA also allows other parameters of the production technology to be explored (Coelli 1996a; Greene 2003; Coelli et al. 2005). SFA is the approach used to conduct the empirical analysis for this study. SFA achieves the objectives of this study by providing a reliable and unbiased measurement of the technical efficiency levels of the Chemical and Pharmaceutical industry in Nigeria. SFA utilises the technique of maximum likelihood to calculate a wide variety of stochastic frontier models, based on Cobb-Douglas and the Transcendental-logarithm (Translog) production functions (Coelli 1996a; Coelli et al. 2005).

3.2 Model specification

The Cobb-Douglas stochastic production frontier model has been commonly used in many manufacturing firm studies in developing countries (Iinuma et al., 1999; Nerrie et al., 1990). This model will be used in the specification of (1) as follows:

$$lnY_{it} = \beta_0 + \beta_1 lnK_{it} + \beta_2 lnL_{it} + \beta_3 lnyear_{it} + V_{it} - U_{it} \dots\dots\dots\dots (1)$$

Where ln= the natural logarithm

Y_{it}= production output (measured by value-added of the i^{th} manufacturing firm in the t^{th} period).

K = fixed assets (a proxy for capital)

L = No of employment (a proxy for labour)

Year= time

V_{it}= a disturbance term with normal properties as explained above.

U_{it} = firm-specific error term as defined in equation (1)

β_1, $\beta_2$and β_3= regression coefficients of inputs (input elasticities)

The justification for the use of these input variables is based on the fact that these variables have been used by previous studies to measure efficiency in the manufacturing industry. Some of the studies include Fahmy-Abdullah et al.(2018), Machmud et al.(2018) Majumdar & Asgari(2017) Smriti & Khan(2018) and Ogunbadejo et al. (2022).

Where technical inefficiency effects are assumed to be defined by

$$U_{it} = \delta_0 + \delta_1 age_{it} + \delta_2 size_{it} + \delta_3 kint_{it} + \delta_4 mgt_{4it} + \delta_5 year_{it} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (2)$$

WhereU_{it}, δ and ε are as defined earlier.

Age= age of the firm (years)

Size= firm size (proxy by total assets)

Kint= capital intensity (measured as Capital-Output ratio i.e. ratio of capital employed to total sales)

Mgt= management efficiency (measured as Net profit after taxes as a percentage of sales)

Year= time

The stochastic frontier production function in (1) can be viewed as linearized variables of the logarithm of the cob- Douglass production function.

The inefficiency frontier model (1) - (2) accounts for both technical change and time-varying inefficiency effects. The Year variable in the stochastic frontier (1) accounts for Hicksian neutral technology change. However, the Year variable in the inefficiency model (2) specifies that the inefficiency effects may change linearly over time.

3.3 Data and Variables

The study adopted firm-level panel data of fifteen formal manufacturing firms quoted in the Nigerian Stock Exchange (Portland paints and Products Nigeria Plc, Paints and Coating Manufactures Nigeria Plc, Berger paints Niger Plc, Premier paints Plc, Chemical and allied products Plc, DN Mayer Plc, IPWA Plc, Neimeth International Pharmaceutical Plc, May& Baker Nigeria Plc, Morrison Industries Plc, GlaxoSmithKline Consumer Nigeria Plc, Nigeria-German Chemicals Plc, Pharmco DekoPlc, Fidson Healthcare Plc and Evans Medical Plc.) that covers the period 2000–2019 to estimate the model. Secondary data of Production output (measured by value added of the i^{th} manufacturing firm in the t^{th} period), fixed assets (a proxy for capital) and the number of employment (a proxy for labour), age of firm (measured by the difference between the current year and year of listing) firm size (proxy by total assets); capital intensity (measured as Capital-Output ratio i.e. ratio of capital employed to total sales); management efficiency (measured as Net profit after taxes as a percentage of sales) and financial leverage (measured as the ratio of total debt to total assets).

4. RESULTS AND DISCUSSION

4.1 Hypotheses test

The frontier production function defined by Equation (1) and the inefficiency model defined by Equation(2) is estimated simultaneously by using the maximum likelihood estimation method for Chemical and Pharmaceutical manufacturing firms.

Since technical efficiency estimates are sensitive to the specification of the production function we have conducted the test for variances restrictions on the translog production frontier to check the appropriateness of the model by the data. For this we use the generalized likelihood ratio (LR) as defined here:

$\lambda = -2\ [RLLF - ULLF]$

$-2(-433.761+456.795) = 46.068$ (3)

Where,

RLLF = the log-likelihood value of the restricted frontier model as specified by the null hypothesis H_0 and,

ULLF = the log-likelihood value of unrestricted frontier model value allocated as hypothesis H_1.

From the reported results of the *generalised likelihood ratio test LR* in Equation (3), it can be concluded that the null hypothesis was accepted at a 95% level of confidence with a preference for the Translog Frontier functional form to represent this panel data. According to the latter, it would seem to be possible to distinguish the significant and positive effects of two inputs *labour*(*L*), and *capital* (*K*) on output in the fitted frontier production function. From the literature point of view, this appears to be reasonable and consistent with the conclusions reached in previous studies with similar weights of labour and capital coefficients Yen (2014),

The Translog Frontier Model was found to be an adequate representation of the data, given the specification of the corresponding Cobb Douglas production function. The values of the logarithm of the likelihood function for the Cobb Douglas and Translog Frontier Model were -433.761 and -456.795, respectively. As a result, the generalized likelihood ratio test statistics came out to be 46.07, which is greater than the critical value of 17.755 (obtained from Table 1 in Kodde and Palm (1986) at a 1% level of significance.

Therefore, the null hypothesis was rejected at the 1% statistically significant level. The finding is consistent with the results reported by Iinuma, Sharma and Leung (1999); Chiang, Sun and Yu (2004); Onumah and Acquash (2010) and Ogunbadejo et al.(2022).

Table 1 Tests of hypotheses for model specification and statistical assumptions.

Null Hypothesis	Test Statistics	Critical Value	Decision
H_0: $\beta_{ij} = 0$	46.068	17.755	H_0Rejected
H_0: $\gamma = ð_1 =.. ð_5 = 0$	47.546	17.791	H_0 Rejected
H_0: $\gamma = 0$	7.474	5.14	H_0 Rejected
H_0: $ð_0 = ð_1 = \ldots ð_5 = 0$	72.022	16.074	H_0 Rejected
H0: ð1 = 0 (no age effect)	-0.271	-4.848	H_0 Rejected
H0: ð1 = 0 (no size effect)	0.3694	7.459	H_0 Rejected
H0: ð2 = 0 (no capital intensity effect)	-0.086	-2.713	H_0 Rejected
H0: ð4 = 0 (no management efficiency	-0.2586	-2.717	H_0 Rejected
H0: ð1 = 0 (no time effect)	-0.298	-4.848	H_0 Rejected

Source: Authors' compilation from FRONTIER 4.1 output.

The first column of Table 1 represents the restriction imposed or the null hypotheses. The second column represents the calculated test statistic. The third column represents the critical values for the test statistic present in column three. The fourth column represents the decision i.e. whether the restriction is valid or not or null hypothesis is accepted or rejected. In Table 1, the first null hypothesis tested is that technical inefficiency effects are absent from the model. The omission of Ui is equivalent to imposing the restriction specified in the null hypotheses i.e. Ho : $\gamma = \delta 0 = \delta_1 = \delta_2 = \delta_3 =$ .... $= \delta_{10} = 0$ The generalized likelihood ratio (LLR) test statistic of 47.546, which is larger than the critical value of 17.791. Thus we reject the null hypothesis of no technical inefficiency effects, given the specifications of the stochastic frontier and inefficiency effect model. The second null hypothesis or resection considered in Table 1 is Ho: γ =0, which specifies that technical inefficiency effects are not stochastic. If the parameter γ is zero, then the variance of the technical inefficiency effect is zero and so the model reduces to the traditional mean response function in which all inefficiency variables are included in the production function. However, if the γ parameter is equal to zero, then the δ_0 parameter is not identified, given that the production function has an intercept. When this restriction was imposed, this provides a generalized likelihood ratio test statistic of 7.474, which is larger than the critical value of 5.14. Thus, the null hypothesis that the technical inefficiency effects are not random is rejected.

Another question of particular interest to this study is whether the five firm-specific factors, considered in the inefficiency model, have a significant influence on the degree of technical inefficiency associated with the chemical and pharmaceutical industry. Thus a test of null hypothesis that, Ho: $\delta_0 = \delta_1 = \delta_2 = \delta_3 =$ .... $= \delta_5 = 0$ is conducted. When this restriction was imposed on the model, the likelihood ratio test statistic of 72.02, which is larger than the critical value of 16.07. Thus the null hypothesis that seven firm-specific factors do not influence technical inefficiency is also rejected.

This indicates that the joint effect of these five explanatory variables on the levels of technical inefficiencies is significant and the individual effects of some of the variables are statistically significant.

4.2 Estimated Parameters of the SFPF

Table 2 presents the estimation results, which suggest that *γ,* the estimated variance parameter, is highly significant and inefficiency effects have a significant impact on industrial output.

The estimates of the coefficients in the stochastic frontier model 3 have the expected sign. It can be observed from Table1 that the co-efficient of the time variable is negative and statistically significant for Chemical and pharmaceutical manufacturing firms. This indicates that the rate of technical progress is negative and statistically significant for this sector during the study period. There is an inward shift in the production frontier in the case of technical progress as the frontier firms experience stagnant technology.

The co-efficient of *L* (*i.e.* labour elasticity) is positive and significant at a 1%level whereas the co-efficient of *K (capital)* is not statistically significant. This indicates that labour rather than capital has played a more dominant role in this industry.

There exist diminishing marginal productivities for capital and labour since the coefficients of $(K)^2$ and $(L)^2$ are negative and statistically significant.

The coefficient of (*K*)*(*L*) is positive and statistically significant. This suggests that capital and labour are substitutes for each other. This result is in line with the findings of Ogunbadejo et al.(2022).

Table 2: Maximum likelihood estimates of Stochastic Frontier Production Function and technical inefficiency model.

Stochastic function dependent variable Ln VA=(ln value-added output	Model 1 Two-1nput and time-invariant stochastic frontier production function	Model 2 Two-1nput and time-varying stochastic frontier production function	Model 3 Five input and stochastic function Translog production function
C	5.56767 (0.52926)	5.87712 (0.49614)	18.78972*** (2.56226)
Ln K	0.19456 (0.04346)	0.26463 (0.04300)	0.45266* (0.41762)
Ln L	1.08947 (0.10044)	1.15542 (0.09328)	2.2944** (1.02800)
Time		-0.33933 (0.06749)	-0.32011*** (0.06549)
Ln K^2			-0.02766 (0.02761)
Ln B^2			-0.00046 (0.11353)
Ln (K*L)			0.278758** (3.11167)
Inefficiency function			
Constant	-3.15382 (0.59379)	-3.27569 (0.60077)	-3.08938 (0.59405)
Age	-0.62037 (0.07718)	-0.48195 (0.08793)	-0.28891 (0.08694)
Size	0.38479 (0.04375)	0.33394 (0.04477)	0.29134 (0.03264)
Kint	-0.12265 (0.03231)	-0.10407 (0.03301)	-0.09560 (0.03264)
Mgt	-0.36786 (0.09687)	-0.31227 (0.09897)	-0.28691 (0.09178)
Time		0.01422 (0.06331)	0.09560 (0.06158)
Log-likelihood function	450.573	437.498	421.526
Gamma(*γ*)	0.7503	0.7458	0.7692
No. obs. (K)	315 (9)	315(10)	315 (10)
Mean efficiency			0.4886

Source: Authors' compilation from FRONTIER 4.1 output.

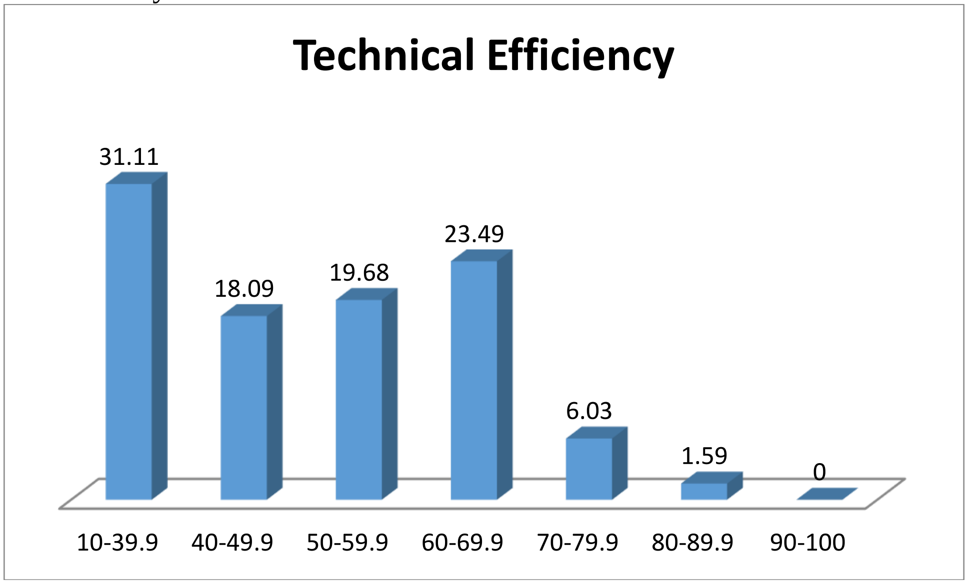
The interaction between capital and labour input is positive and highly significant at a 1% level of significance indicating that the contribution of capital and labour input to the industrial output value is increasing.
However, the return to scale (RTS), computed as the summation of output elasticities, is estimated to be 2.43, which denotes that on average, the manufacturing firms have an increasing return to scale (stage I of production). The implication is that if the sample firms increase all the factors of production by 1%, the output would also increase by another 2.43% and the industries would be better off. The estimated RTS is similar to those reported by Ogunbadejo et al.(2022). In Table 2 model 3 the value of the variance parameter, *Gamma* (γ) which lies between 0 and 1 is equal to 0.769. It, therefore, confirms the presence of stochastic technical inefficiency and that indicates its relevance to obtaining an adequate representation of the data (Battese&Corra, 1977).
It also indicates that the variance of the inefficiency effects is a significant term of the total composite error term variance, and therefore the deviations from the optimal level of output in the Nigerian manufacturing industries subject to study are due to both the random exogenous factors and inefficiency existence in the production processes. In other words, this implies that the stochastic production frontier is significantly different from the deterministic frontier which does not comprise a random error.

4.3 Technical inefficiency model

In the inefficiency model in Table 2, a positive coefficient indicates an increase in inefficiency since the variables are determinants of inefficiency. The coefficients of firm size are negative and significant at a 1% level of significance for the chemicals and Pharmaceuticals. This implies that the level of technical efficiency is higher for larger firms as such firms can benefit from economies of scale. This finding was in line with Ugbam and Okoro (2017) who asserted that larger firms are more efficient in the pharmaceutical industry in Nigeria. A larger firm may have an access to the superior quality of inputs, which helps to enhance its efficiency level. The co-efficient of age is negative and statistically significant at the 1% level of significance for the Chemical and Pharmaceuticals sector which indicates that other things remaining unchanged, an experienced firm is technically more efficient than newly established firms. This result was in line with Lee et al (2010) also find a similar result was Ogunbadejo et al. (2022).
The coefficient of management efficiency has a negative and statistically significant 1% level of significant impact on technical efficiency. The management efficiency variable is a proxy used to capture the effects of good management Practices (GMP), this is an indication that those industries that have adopted GMP in their firms have lower technical inefficiencies (i.e. are more efficient) than those who have refrained from doing so.
The coefficient of capital intensity has a negative and statistically significant impact on technical inefficiency. This indicates that the more ratio of capital employed to total sales the more efficient the firms with less capital-output ratio.
The co-efficient of time *t* is positive and significant which indicates that the average efficiency of firms has declined in the Chemical and Pharmaceuticals sector. So, several firms have failed to appropriate the benefits of technological progress. The distance from the frontier has increased for an inefficient firm since there has been an outward shift of the production frontier as other firms have experienced technical progress.

4.4 Technical efficiency estimate

The predicted technical efficiencies of the individual sample firms together with the estimated mean technical efficiency of the industry is around 48.8 percent and ranges between 82 and 1.2 percent. The mean technical efficiency scores across the model and samples were compared using a t-test and the difference between the mean scores was found to be statistically significant. There is about 31.1 percent of an industry that has efficiency scores between 0 to 30 percent which is troubling as these industries are extremely inefficient.



Thus, 93.2% of the individual sample firms in the study have TE scores less than 70%. This shows that the majority of the Chemical and pharmaceutical firms are operating far below the production frontier and can substantially improve their income levels through better practices and the adoption of feasible technologies.

5. CONCLUSION AND POLICY RECOMMENDATIONS

This study aims to examine the level of efficiency and analyze the factors that determine the inefficiency of the Chemical and pharmaceutical manufacturing industry in Nigeria. Data was sourced from the various issues of the annual report and statement of accounts of these firms and also from the various issues of the Nigerian Stock Exchange Fact Book involving 15 firms obtained from 2000 - 2015. Based on the results through the Translog production function, the level of efficiency of the Chemical and Pharmaceuticals manufacturing industry in Nigeria is low with a range of efficiency of 0.488. Furthermore, the results show that determining factors including age, size, capital, management and year play an important role in reducing the inefficiency of a firm's technique as the findings of previous studies include Bertrand (2013), Fahmy-Abdullah et al. (2017) and Ogunbadejo et al.(2022). We found evidence of considerable technical inefficiency among the industries in Nigeria and the results show that efficiency varies from 1.2 to 82 percent and the mean efficiency is 48 percent which suggests that given the existing technology and input usage output can be increased by 52 percent on average.

In terms of policy implication, this finding emphasizes that the Chemical and pharmaceutical manufacturing industry still needs a lot of effort to further improve its efficiency level, especially by emphasizing the determinants that can improve firm efficiency. Enhancement of input efficiencies (e.g., more skilled labour) to be able to move toward their most efficient production frontier given current technology, and utilization of improved technology that helps shift their current frontier outward.

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