Article title: Operational Resources Management In An Increasingly Digitized Business Environment: Technical Efficiency Analysis of Nigerian Brewery PLC from 2012-2021

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Abstract
Achieving efficiency in planning, execution, and management of operational resources in a competitive business environment has been the major challenge of modern businesses. This study researched functional resource management in an increasingly digitized business environment factoring technical efficiency analysis of the Nigerian Brewery Plc. from 2012-2021. The study used annual and quarterly reports to analyze the operational performance for ten years. Cost minimization (input-oriented model) and revenue growth (output-oriented model) are precedents in the stochastic production approach and Farell's efficiency theory, respectively. A series of analyses were performed on python using five different regression algorithms (Decision tree, Polynomial, Random forest, simple linear, and multiple linear regression algorithms). The analysis's findings did not definitively confirm or refute the theories on whether the Nigerian Brewery Plc. is technically efficient or not based on confusion matrix of multiple linear regressions, which had a 92 percent accuracy level. However, it was established that for ten years; the company has been able to perform efficiently in some years and did not do so well in others. The study found that the labor force and production machinery were operating below expected capacity. Also, there was a high cost of raw materials and operational expenses commiserated with the output. The study, therefore, recommended that to achieve maximum efficiency, the company should implement strict monitoring measures and adopt direct labor costs on the labor force; where piece rate wages payment should be employed on hours spent on the job to reduce sloth and increase the functional performance of the company.

Key Words: Operational Resources Management, Digitized Business Environment, Technical Efficiency, and Nigerian Brewery.
1.0 Introduction and Background of Study

Operations Management is a systematic design, direction, and control of processes that transform inputs into products or services for internal and external users [11]. It is viewed as a systems oriented and highly integrative study of methods, tools, processes, and techniques that coordinate people, systems, and processes with physical and natural resources. It is achieved by generating value and delivering value to meet organizational objectives and consumer demands at reasonable acquisition, production, and distribution costs [3].

The department of operation resource management is very crucial for the progress of every manufacturing or production organization. Its relevance stems from the numerous roles and functions performed by operation resource managers. The sole driving force for resource management is the need to improve productive efficiency; cost reduction and profit maximization due to continuous increases in customer demand and the need for organizational efficiency. There are thirteen brewery companies in Nigeria, however, only four are listed on the floor of the Nigerian Stock Exchange [6]. These include the Nigerian Brewery (NB), International Brewery (IB), Champion Brewery (CB), and Guinness Nigerian Brewery (GNB). The Nigerian Brewery PLC was selected for this study because of its role in contributing to the economic growth of the Nigerian Economy as one of the top biggest non-oil sector economies.

The Nigerian Brewery PLC started in 1946 as the country's first and biggest brewer. The brewery was built starting in 1947 at Iganmu, Lagos, and was finished in 1949. The 21 brands which are loved locally and internationally were added to the company's portfolio over time, along with an unequaled selection of non-alcoholic, stout, and spirited beverages. The company is customer-centric and dedicated to diverse products that cater to its growing consumer expectations. It also has high-quality brands, ethically sourced raw materials, and consumer satisfaction. The global beer sector contributes to Nigeria’s economy through its domestic and international operations, and worldwide supply chain. It sustained over 309,000 jobs in Nigeria in 2019 [8]. The global beer sector also supported $526 million in tax revenues and a $2.2 billion Gross Value Added contribution to Nigeria’s GDP in 2019.
According to the research authored by Oxford Economics on behalf of the Worldwide Brewing Alliance (WBA), the brewery industry generates 262 billion USD in government tax revenue in the 70 countries studied, which account for 89% of beer sold worldwide and aided an estimated 23.1 million jobs. However, the interim report for the 1st -a quarter of 2021 shows that the company started the year with a total debt profile of about N91.5 billion up from N55.7 billion a year earlier [7]. The company tapped loans from the FMDQ via commercial papers sold to investors leveraging on cheap borrowing costs in the pandemic year. This research aims to measure the technical efficiency of Nigerian Brewery (NB) Plc. from 2012-2021. More specific objectives include an identification and determination of technical inefficiencies of the NB Plc. and an examination of the time-variant or invariant of the efficiency of the NB Plc.

The study hypothesized that Nigerian brewery Plc. is technically inefficient while the alternative hypothesis opposes that Nigerian brewery Plc. is not technically inefficient, e.i. it is efficient. Thus, this paper tries to test the null hypothesis that there is an existence of technical inefficiency. The expected major beneficiaries of these findings could be shareholders, potential investors in the business, and regulatory bodies. The study could serve as an input for the brewery industry to strategically and objectively identify their drawbacks and hence, leverage the different variables affecting the efficiency and effectively and efficiently utilize the available resources.

2.0 Review of literature

This section describes various theoretical and empirical reviews of the literature on operational resource management concerning efficiency in production capacity and facility of the brewery sector. The author refers to operational resource management as means for acquiring a better understanding of the cost of goods and services that produce enterprise-wide financial control that streamlines the production efficiency, maintenance, repair, and operations (PEMRO) procurement process (indirect goods) and supply chain control.

The concept of efficiency which is the target of this research is often viewed in social sciences and management sciences alike. In this regard, emphasis is placed on management sciences concerning efficiency in production facility and capacity referred to as Technical Efficiency and
Allocative Efficiency. The researcher used the concept of technical efficiency of a firm as the ratio of its observed output to that, which could be produced by the full capacity utilization firm given the same input quantities. Allocative Efficiency, on the other hand, is the ability of a firm to maximize profit by equating the marginal revenue product of input to their respective marginal costs. The researcher used this concept to refer to an arena or business operating space that utilizes modern techniques, methods, processes, and programs that enable businesses to operate maximally with human intelligence more than human efforts.

2.2 Theoretical Review

This study is anchored on the theory of efficiency as coined by Farrell [5]. Technical Efficiency is defined as inputs needed at best practice to produce observed outputs relative to observed quantities, keeping observed input ratios. It is the overall efficiency as costs of producing observed output if both technical efficiency and price efficiency are measured relative to observed costs. In the choice of a production frontier benchmark, the researcher adopts a more practical approach, starting with econometric considerations and finishing with recommending the application of an observed best practice.

Generally, efficiency measures are completely data-based, no specific functional form needs to be predefined, and follow an input-oriented scheme. The analysis of Allocative Efficiency is based on profit maximization were both cost minimization (input-oriented model) and revenue maximization (output-oriented model) is assumed. From the end of the 1970s onwards, several techniques have been developed for efficiency analysis; these techniques can be classified in various ways. The criterion followed here distinguishes between parametric and non-parametric methods that are, between techniques where the functional form of an efficient frontier is predefined or imposed a priori and those where no functional form is pre-established but one is calculated from the sample observations empirically.

The aim of this non-parametric approach to the measurement of productive efficiency is to define a frontier envelopment surface for all of the sample observations. This surface is determined by those units that lie on it, on the other hand, units that do not lie on that surface can be considered inefficient and an individual inefficiency score will be calculated for each one of them.
separately. A further classification of frontier models can be made according to the tools used to solve them, namely the distinction between mathematical programming and econometric approaches. The deterministic frontier functions can be solved either by using mathematical programming or using econometric techniques. The stochastic specifications are estimated using econometric techniques [15].

2.3 Empirical Review of Existing Methods and Results

In the empirical literature, the stochastic frontier application is predominant in production maximization. Until recently, most of the empirical applications that measured technical efficiency using the stochastic frontier production function approach have been in agricultural economics and operational research.

To effectively utilize the potential of the industries, efforts have to be made in improving investment intensity, export intensity, infrastructural and institutional development, and availability of updated marketing information systems. This aligned with the studies of the technical efficiency of the Ethiopian brewery industries anchored on the stochastic frontier production function model [9].

Lack of capital intensity and labor quality factors in determining the efficiency levels in most manufacturing industries in the world are some of the challenges faced by corporate brewery industries. Singaporean manufacturing industries tend to suffer this setback as backed by researched publications. To achieve maximum production efficiency, industries must breach the gaps in capital intensity and labor quality [11].

Furthermore, material control of the brewery industry in Nigeria has been a huge challenge. Manufacturing firms should develop a policy framework to facilitate faster implementation of material control systems in Nigerian breweries to improve organizational productivity. They should increase their resource commitment to staff training and Research and Development in material planning strategy to develop the necessary skills, update their knowledge, and enhance organizational productivity [4].

Most production engineers lack sufficient technical competence to produce quality products, and therefore, companies need to aggressively adopt a knowledge-based strategy to educate and train their engineers. This view aligns with thoughts and research carried out on the Jos International brewery [13].
In this research, the functional form of the production function efficiency for stochastic production frontier was specified by the Cobb-Douglas model. Specifications such as the Translog provide the opportunity to characterize the data more flexibly. However, the Translog estimates are likely to suffer from degrees of freedom and multicollinearity problems resulting in inefficient estimates [2].

Different methods used to measure technical efficiency can be classified into two groups; parametric and non-parametric [2]. The non-parametric approaches are the category of Data Envelopment Analysis (DEA) which involves the use of econometric linear programming. One of the key advantages of the non-parametric method is the non-imposition of any functional form on the data; whereas the main disadvantage is its assumption of constant return to scale.

The parametric approach, even though it imposes a functional form on the data, it has a significant advantage due to its ability to characterize frontier technology in a simple mathematical form to accommodate non–constant returns to scale. Furthermore, the parametric method is further divided into deterministic and stochastic. The deterministic approach is based on the premise that the production frontier is unique to all firms with a given output level and that the inter-firm variation is attributable only to differences in inefficiency [14].

3.2 Model Specification

In this model, a production frontier defines an output as a function of a given set of inputs. These include raw materials, Fixed capital, Labor (wages and salary), and Power (fuel and energy consumption), together with technical inefficiency effects, which defines the degree to which firms fail to reach the frontier. This could be due to technical inefficiencies of production (i.e. Investment, Loans and borrowings, corporate social responsibilities, and Retirement benefits of workers).

The representation of the model is as follows;

\[ \ln(Y_{it}) = X_{it} \beta + V_{it} - U_{it} \]

For \( i=1,2,3,\ldots,N \) and \( t=1,2,3,\ldots,T \) (Cobb-Douglas general model). \( X_{it} \) denotes a vector of inputs value where \( \beta \) refers to the unknown scalar parameter to be estimated.

A specific model for the study;

\[ \ln(Y_{it}) = L_{it} \beta + M_{it} \beta + K_{it} \beta + P_{it} + V_{it} - U_{it} \]  \( \text{For } i=1,2,3,\ldots,N \) and \( t=1,2,3,\ldots,T \) (2)

Where
Yit= the output of the firm at the given time;
Lit= vector of log of input values of labor at a given time;
Kit= vector of log of input values of capital at a given time;
Vit= are the usual random errors measuring the positive and negative effects;
Pit= vectors of log of input values where power is measured in terms of fuel and energy to generate electricity at a given time;
β =vector of unknown scalar parameters to be estimated;
Mit= vector of log of input values of raw materials at a given time, and
Uit= Uit is a a non-negative random variable that is assumed to account for technical inefficiency in the model.

Note that Xit = Lit + Kit + Mit + Pit (Input values)
The summation of the two random variables Vit and Uit are expressed as eit in which
\[ \sigma^2_e = \sigma^2_v + \sigma^2_u \] and \[ \gamma = \frac{\sigma^2_u}{\sigma^2_e} \] (3)

Technical efficiency of the firm at the time t is defined by: TEit = \exp(-Uit). It measures the extent to which a company operates below the frontier drawn by the production amount during the most efficient years given that working conditions and nature of input are the same or almost the same throughout all the years in a sample. Technical inefficiency effect can be assumed to remain constant or, it can vary over time. The assumption of time-invariant inefficiency considers that the inefficiency of the industry has persistent nature and is time irresponsible. However, this study assumes that technical inefficiency changes over time. The technical inefficiency effects as a function of time are defined as;

\[ Uit = \{\exp[-\eta(t-T)]\}Ui \] (4)

Where i=1, 2,…N and t=1,2…..T (4)

Uit is a non-negative the random variable associated with the technical inefficiency of production. \( \eta \) is an unknown scalar parameter to be estimated, which accounts for whether or not the inefficiencies are time-varying or time-invariant. If \( \eta \) is positive, then \( -\eta(t-T) = \eta(T-t) \) is positive for \( t<T \) and so \( \exp[-\eta(t-T)]>1 \), which implies that the technical inefficiencies of the industry decline over time. If \( \eta \) is zero, then the technical inefficiencies of the industries remain static. However, if \( \eta \) is negative, then \( -\eta(t-T)<0 \), and thus the technical inefficiencies of companies increase over time.
3.3 Description of variables

3.3.1 Explanatory variable and dependent variable.

The researcher implores the following variables to estimate the inefficiency scores and the inefficiency effects.

- **Gross Value of Output (Yit)** - production is the function of the interplay of capital, raw materials, labor, power, and other inputs. Thus, the researcher considers the gross value of output as measured by net sales to be used as the dependent variable.

- **Capital (Kit)** - is fixed capital that represents assets of a company with a productive lifespan of an operating year. It reflects the net book value at the beginning of a reference year plus new capital expenditure minus the value of sold and disposed of machinery and equipment including depreciation during an operating period.

- **Labor (Lit)** - the number of wages and salaries paid to the workers each time is accrued for the labor cost in the frontier productions, this variable includes all payments made to workers during the operating period (i.e. 2012-2021).

- **Power (Pit)** - the electricity used is accessed based on fuel and energy consumption for the brewery industries, which are measured in the monetary value of naira (₦).

- **Materials (Mit)** - include all costs of raw materials used in a course of production, measured in naira (₦).

3.3.2 Sources of technical inefficiency

Arriving at the result which shows that the company is technically inefficient will not be complete unless the sources of inefficiency are identified [1]. The followings are some of the determinants of technical inefficiencies as follows:

- **Investment** – measured as a valuable asset acquired to generate income or appreciation in the future.

- **Corporate Social Responsibilities** - defined by a company’s way of extending its support to the host community.

- **Retirement benefits** - include pension payments and other payments to retirees.

- **Loans and borrowing** - payments on loans for previous periods.

Thus, the model for estimating the determinant of inefficiency is defined as:

\[ U_{it} = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 \] (5)
Where: \( \alpha_0 \) is the intercept term; \( \alpha_j \) (j=1, 2, 3…5), a jth parameter of the intercept is the explanatory variable \( Z_1 = \text{investment}, Z_2 = \text{Corporate Social Responsibilities}, Z_3 = \text{Retirement benefits}, \) and \( Z_4 = \text{Loans and borrowings}. \) After regressing technical inefficiency on the above determinants, we can test the significance of each variable. The result will demonstrate whether there is a technical inefficiency or not.

**Diagram 1. Conceptual organogram of production function in Nigeria Brewery.**

Source: Solution-based conceptual model of production.

From diagram 1 above, input resources are received from the production and logistics department. These resources are forwarded to the transformation stage occupied by various representatives from the functional departments. A decision is reached after the transformation and sent to quality assurance; corrections are made, and then forwarded to production for execution. The final output is achieved. Feedback and feed-forward report is communicated to the top management and lower-level workers.
4. Results, Findings, and Discussion
The study examined the technical efficiency of Nigeria brewery Plc. using secondary data. The data used for analyzing the variables that affect brewery efficiency are between 2012-2021. Annual accounts and reports of the company for the past ten years (2012-2021) were considered secondary data. The data were tested on five regression algorithms. These include decision trees, polynomials, random forests, and Simple linear and multiple regression algorithms. The researcher, however, adopted multiple regressions to analyze the stochastic production function. Recall the conceptual model: \( \ln(Y_{it}) = L_{it}\beta + M_{it}\beta + K_{it}\beta + P_{it} + V_{it} - U_{it} \).

The linear regression equation of the result is as follows:
\[
\ln(Y_{it}) = -3.28\beta + 1.70\beta + 2.31\beta + 9.99\beta + 7.54\beta - 3.08\beta + 1.15\beta - 5.98\beta - 0.5e + 10.50
\]
The above values in the equation represent the Labor, Materials, Capital, Power, and other variables considered in the conceptual model in addition to error terms and constants. For instance, Labor represents \(-3.28\beta\) means that there are workers in the organization who are not putting in effort in the production process. Therefore, the labor force could reduce by \(3.28\beta\). Similarly, materials and other positive resources \((+1.70\beta + 2.31\beta + 9.99\beta + 7.54\beta)\) used in the model should increase. If this is achieved, the output of the firm \(\ln(Y_{it})\) will efficiently be attained.

Diagram 2. Result of Net revenue Vs. yearly polynomial regression

Source: Author’s Net revenue Vs. Yearly polynomial regression.
From Diagram 2 above, the total net revenue of the company unevenly increased. There was a sharp decline in revenue in 2015, 2017, and 2018. These declines account for the inefficiencies in the operation of the company. However, the company recorded the highest net revenue in 2021. It shows a significant efficiency improvement after the Covid-19 era of 2020.
The individual performance of input variables was examined by the measure of the performance of fixed capital to net revenue. It was also revealed that no single input variable could significantly improve revenue and hence the coefficient matrix showed an output result of 0.125 representing 12.5 percent. To achieve efficiency in management operations, effective and efficient utilization of input variables must be achieved.

Diagram 3. Result of Net revenue Vs. Fixed capital

Source: Author’s Net Revenue Vs. Fixed Capital.

The study suggested the sources of technical inefficiencies model in the company include explanatory variables. The model looks as follows: $U_{it} = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4$.

Where: $\alpha_0$ is the intercept term; $\alpha_j$ (j=1, 2, 3...5), the jth parameter of the intercept is the explanatory $Z_1 =$investment, $Z_2 =$ Corporate Social Responsibilities, $Z_3 =$ Retirement benefits, and $Z_4 =$ Loans and borrowings. By fitting the result into the model, we have $U_{it} = -105036126905.00311 + \alpha_1 (-3.08e+00) + \alpha_2 (1.31e+00) + \alpha_3 (-8.17e-01) + \alpha_4 (3.61e+00)$

The model represents the sources of technical inefficiencies in production operations. The values with negative signs indicate that the company needs to reduce its spending on investment, and minimize retirement benefits and the cost and terms of obtaining loans and other borrowings respectively.

Testing the hypothesis
Based on the available data to the researcher and the result of the analysis, it is, however, not sufficient to conclude that the Nigerian Brewery Plc. is technically efficient or inefficient. However, more negative tendencies of inefficiencies were advanced.

The model predicted these results for the year 2022:

\[ In(Y_{it\ 2022}) = [2.66e+11, 3.37e+11, 3.45e+11, 3.24e+11, 2.66e+11, 3.14e+11] \]

The model predicted that if the input variables are maintained and other variables are held constant, there will be no significant increase in the company’s revenue or output.

4. Conclusion and Recommendation

The study examined operational resource management in an increasingly digitized business environment, the case of the Nigerian Brewery plc. Farell’s efficiency theory was used and sought to validate or invalidate the hypotheses that Nigerian brewery is technically inefficient or not. Five regression algorithms were used to analyze the data, however, only the multiple regression approach was more appropriate as it produced an accuracy rate of 92 percent using the confusion matrix. The findings and the result of the analysis of data as published on the company’s website proved insufficient to conclude whether the company is technically inefficient or otherwise. The study suggested that to maximize operational efficiency, more robust efforts have to be made to reduce human efforts. This stays in line with the findings that there was underutilization of the labor force. Invariably, it means that certain categories of the labor force were operating below capacity. A piece rate payment system should be adopted to promote worker participation to reduce direct labor costs on input variables and overhead expenses.
References


[8] NB Interim 4th Quarter Report, 2019


# visualizing the performance of Fixed capital vs the Net Revenue

![Graph showing the performance of Fixed capital vs the Net Revenue](image)

# USING RANDOM FOREST REGRESSION TO DETERMINE THE IMPACT AND CORRELATION OF FIXED CAPITAL ON THE NET REVENUE.

```
[[0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0]]
```

```
Out[39]: 0.125
```

# predicting the Test set results
```
[[2.66e+11  2.76e+11]
 [3.37e+11  3.38e+11]
 [3.45e+11  3.55e+11]
 [3.24e+11  3.33e+11]
 [2.66e+11  2.71e+11]
 [3.14e+11  3.15e+11]]
```
```python
print(regressor.coef_)
print(regressor.intercept_)
```

```
[-3.28e+08 -6.73e+07 1.70e+09 -3.54e+09 2.31e+09 7.90e+08 9.99e+07
 -9.68e+08 7.54e+07 -6.99e+07 -3.08e+00 1.05e+00 1.15e+00 1.31e+00
 -1.61e-01 -8.17e-01 -5.98e+01 3.61e+00]
-105036126905.00311
```

```python
plt.scatter(X, y, color = 'red')
plt.plot(X, lin_reg.predict(X), color = 'blue')
plt.title('Efficient or Inefficient (Linear Regression)')
plt.xlabel('Year')
plt.ylabel('Net Revenue')
plt.show()
```

---

**In [208]:**  # Evaluating the model performance

**In [209]:**  from sklearn.metrics import r2_score

```
R2_score = r2_score(y_test, y_pred)
```

**Out[209]:**  0.9999999999993234

**In [210]:**  print(y_test)

```
[266372475000 337006267000 344527517000 324389500000 266372475000
 313743147000]
```

**In [211]:**  print(y_pred)

```
[2.66e+11 3.37e+11 3.45e+11 3.24e+11 2.66e+11 3.14e+11]
```