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An Estimation of Production Function of Selected Airports in Nigeria

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Abstract

This study analyzes the production function of selected airports in Nigeria using the Data Envelope Analysis approach. The result creates a production function frontier for the airports and compares the airport's actual productive efficiency with that of the frontier. Panel data was used. Production function specifications are described herein, considering that technical inefficiency effects determine the airports that are operating below the frontier. The estimations of the production frontier are determined from the Data Envelope Analysis frontier estimate result using the linear programming model function. Various input variables or parameters used for the analysis were determined using the data envelope analysis for the model estimate. The input variables (parameters) are terminal capacity, number of employees, total assets, and total cost, while the output variables (parameters) are passenger and aircraft movement. The results of the analysis reveal that all the airports studied for the given period produced an efficiency score of high productivity. The result also shows an airport efficiency score of 100%, which is equal to 1 for a productive and efficient airport. The result also shows a production function for the airports and exhibits the airports operating under constant return to scale and variable return to scale. The model estimates various economies of scale of all the airports during the study period, and policy implications were made on how to benchmark the airports using the efficiency airports. Recommendations were made on how to use the findings to set a policy for the government, as they are working towards the privatization of some airports in the country.

Keywords: *Airport, Productivity, Efficiency, Input, and Output*.

1.0 Introduction

The movement of people and goods by air from one area to another is known as air transport. The aircraft used for it range in size and specification from small propellers to enormous Boeing aircraft. The airport, which includes the terminal building, the runway, and other crucial elements of the air transportation system, is the primary piece of aviation infrastructure. For passengers who want to go by air, the airport is the first place to contact them. As a result, it is critical that our airports meet standards and live up to the expectations of the travelers who use them. As a result, it is critical that our airports meet all requirements and meet the expectations of the travelers who use them, since it is crucial to provide visitors with a positive first impression in order to promote their continued use of air travel. For the purposes of this study, we will evaluate the productive efficiency of a few chosen airports in Nigeria to determine how well or poorly they are thriving to make the required modifications for better airport service and air travel overall where appropriate. The aviation industry has expanded quickly over the past three (3) decades and is currently the most significant transport industry in the world. Customer demand for air transportation services has increased as globalization becomes more pervasive. For a long time, airports have assumed a crucial role in the aviation industry as they serve as a key piece of infrastructure and support the rising demand for transportation (Gok, 2012).

One of the most significant sectors in the world is air transportation. It is a significant contributor to the improvement of contemporary social development through its technological advancements and development. Due to its complexity and ongoing advancements, no other significant mode of transportation has expanded as rapidly as the aviation industry. The economic and tourist development of the country and the world have greatly benefited from the aforementioned. Demand for air transportation services has enhanced the sector's importance to the national and international economies, facilitating the quick movement of people, products, and services to both domestic and international markets. The quick exports of goods and services, really contributes to the economy's ability to create more revenue. For people all across the world, the aviation sector is crucial for both work and leisure. The sector aids in advancing and raising the living conditions, standards of living, and general well-being of the populace. All of this contributes to economic growth and the reduction of poverty by creating job opportunities and raising tax revenues. The airports' revamping of the supply chain would create employment opportunities (Nwaogbe et al., 2013).

Nigeria is the country with the biggest population in Africa; with this population, the government is working to enhance its transportation infrastructure, particularly the aviation sector, to handle the international traffic that arrives at its airports, according to Nwaogbe et al. (2015). Airports around the entire nation, both local and international, are part of the development. Nigeria wants to serve as a hub for the West African region and all of Africa in terms of commercial activity and aviation transportation. Because of this, the Nigerian government and the transportation industry have recently shown a strong interest in reviewing the overall effectiveness, productivity, and efficiency of the nation's aviation sector. As the only industry that can move people and goods quickly and safely over international borders as well as within Nigeria, the air transportation sector plays a crucial role in Nigeria. This helps to make both passenger and freight transportation particularly sustainable. Therefore, the airport/aviation sector is a crucial component of the transportation infrastructure that is essential for the social and economic advancement of the nation.

The competition in the airport environment has been steadily increasing over the past year since different airlines and airports across the world are attempting in one way or another to get all of the consumers to utilize their neighbouring nations' airports or even the closest airport to it. The countries have a variety of mineral resources that are drawing a lot of passenger traffic, and this has resulted in a continuous rise in economic development. We must conduct studies on passenger movements to figure out how to keep both the airlines and the passengers operating in the airports in order to maintain this traffic. This will allow them to maintain the boom of various investments in the ECOWAS region, while others are attempting to turn their countries' port terminals into airports. For instance, Ghana and Nigeria are attempting to compete with one another in terms of air transportation services, particularly with regal about Nigeria and Ghana are both attempting to serve as hubs. However, the country has lost its position as Ghana's primary aviation hub because of the recession in Nigeria and the aviation fuel crisis. It is obvious that competition and ongoing analysis of airport performance are necessary to improve continuous quality rehabilitation at our airports within the region.

An airport is a crucial part of a nation's economy since it links local enterprises, institutions, and residents to new markets, business prospects, and friends, relatives, and families around the globe. The majority of airports in use today are wholly owned by governments. The national or municipal government not only owned them but also ran them. However, with the emergence of privatization and commercialization in the aviation industry, the role of the government in the ownership and management of airports has evolved substantially over time (Oum et al., 2008). The traditional management and regulation of an airport as a public utility is still in use in many countries. A global privatization trend developed throughout the 1980s because of the privatization of the BAA (British Airports Authority), and it has been supported by regulatory reforms towards incentive and lenient regulation. Our airports are now exposed to a variety of competitions because of deregulation, and each airport wants to stay up to date with the norm and current trend of international operations. Many researchers have said that each airport has its own characteristics, which could be in terms of finance, operations, environmental factors, or even technical variables, which might make comparisons yield a misleading result. However, airports are constantly subject to benchmarking analysis with the aim of ranking them according to their productivity and efficiency scores (Oum et al., 2008).

Wanke, Barros, and Nwaogbe (2016) to evaluate the productive efficiency of Nigerian airports used Fuzzy-DEA in a study. They employed fuzzy DEA to analyze the effectiveness of the airport's operational efficiency. Fewer significant contextual variables are found to be efficiency drivers, according to their findings. Capacity cost, together with a learning component represented by trend, was discovered to be the sole meaningful variable after correcting for fuzziness and unpredictability. To maintain the learning curve, policy design for Nigerian airports should concurrently promote techniques of continuous improvement and third-party capacity management, such as privatization.

Using a linear programming paradigm, Data Envelopment Analysis will be used to answer the presented research problem. In 1978, Charnes, Cooper, and Rhodes introduced DEA, sometimes known as frontier analysis (CCR). Using the performance measuring method known as DEA, one can assess the relative effectiveness of a decision-making unit (DMU). The DMUs will now operate out of airports. Efficiency is the ratio between the actual production produced, the standard output anticipated, which is derived from, and a component of productivity achieved (Sumanth, 1984). Following is how Mali (1978) combined the concepts of productivity, effectiveness, and efficiency.

Productivity index = $\frac{output\ obtained}{input\ expected} = \frac{Performance\ achieved}{reources\ consumed} = effectiveness/efficiency$

Therefore, Sumenth (1984) and Ramanathan (2003) express efficiency as follows:

$$\text{Efficiency} = \frac{output}{input} \tag{1}$$

$$\text{Efficiency} = \frac{U\ weighted\ sum\ of\ outputs\ of\ DMU}{v\ weihted\ sum\ of\ inputs\ of\ DMU} \tag{2}$$

If all weights are assumed to be uniform, this can be expressed mathematically as follow:

$$\frac{\sum_{r-1}^{n} u_r y_r}{\sum_{r-1}^{n} v_s x_s} \tag{3}$$

Where $y_r =$ quantity of output r

u_r = weight attached to output r

x_s = quantity of inputs

v_s = weight attached to inputs

The Eficiency of airport can be denoted as = 1, so to classify unit efficiency of the airport is set as 0 < Efficiency ≤ 1 (Mokhtar & Shah, 2013).

1.1 Model formulation

1.2 CCR-model

The variables and parameters needed to conduct the investigation are employed in the model's formulation. In light of this, the following variables and parameters form the basis of the model:

1.3 Model parameters and assumptions

n = number of airports (DMUs) $\{j = 1, 2, \ldots \ldots., n\}$

y = number of outputs $\{y = 1, 2, \ldots \ldots \ldots., R\}$

x = number of inputs $\{x = 1, 2, \ldots \ldots \ldots., S\}$

yi = quantity of output r^{th} of output of j^{th} DMU

xi = quantity of input s^{th} of input of j^{th} DMU

ur = weight of r^{th} output

vs = weight of s^{th} input

Golany & Roll (1989) discuss the homogeneous unit as an important component in picking the DMUs (airports) to be compared and identify the factors that affect the DMUs while looking at the airports (DMUs) and homogeneous units. In terms of objectivity and performance, each DMU with the same collection of units will act in the same manner. They currently operate in the same market and track its current state. The same inputs and outputs that improve benchmarking and performance evaluation apply to both. The model can compare the relative efficiency of the DMUs using a formulation of the linear programming model for the airports. In order to address the production frontier of a few particular airports in Nigeria, we have used the Charnes et al. (1978) model.

Objective function : $Max_{\theta\lambda}\,\theta_j$

Subject to:

$$\sum_{i=1}^{n} \lambda_j\, y_{ri} \geq y_{j\,;}\; r = 1, \dots \dots, R \qquad (4)$$

$$\sum_{i=1}^{n} \lambda_i\, x_{si}, \leq \theta_{j\,;} x_{j\,;}\; s = 1, \dots \dots, S \qquad (5) \qquad \lambda_i \geq 0;\ \forall_i \quad (6)$$

Where $y_i = (y_{1i}, y_{2i}, \dots \dots \dots, y_{Ri})$ is the output vector, $x_i = (x_{1i}, x_{2i}, \dots \dots, x_{Si})$ is the input vector, λ is a 1x1 vector constants. Solving the equation for each one of the n airports of the sample size, n weight and n optimal solution are found in the linear programming problem. Each optimal solution $\boldsymbol{\theta}_j^*$ is the efficiency indicator of the airports j and , by construction it satisfies $\boldsymbol{\theta}_j^* \leq 1$. These airports with $\boldsymbol{\theta}_j^* < 1$ are considered inefficient and airports with $\boldsymbol{\theta}_j^* = 1$ are efficient.

1.4 BCC-model

Modifying the Charnes et al. (1978) model constant return to scale (CRS) by Banker et al. (1984) by adding the restriction $\sum_{i=1}^{n} \lambda_i = 1$, that generalises the model to variable return to scale (VRS) of the BCC-model as stated. Consider a set of n observations on the DMUs: each observation $DMUj\ (j = 1, \dots \dots n)$ uses m inputs $x_{ij}\ (i = 1, \dots \dots, m)$ to produce s outputs $y_{rj}\ (r = 1, \dots \dots, s)$. DMU_o represents one of the n DMUs under evaluation, and x_{i0} and y_{r0} are the ith input and rth output for DMU_o, respectively. The envelopment models for the VRS frontier type are stated below, Variable Returns to Scale (VRS), also known as BCC (Banker et al., 1984), where ε is a non-Archimedian element and s_i^- and s_r^+ account, respectively, for the input and output slack variables (Bazarghan & Vasigh, 2003; Zhu, 2003).

Objective function: Max $\emptyset - \varepsilon(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+)$

$s.t.$

$\sum_{j=1}^{n} \lambda_j \; x_{ij} \; + \; s_i^- \; = \; x_{i0} \;, \forall i$ (7)

$\sum_{j=1}^{n} \lambda_j \; y_{rj} \; - \; s_r^+ \; = \; \emptyset y_{r0} \;, \forall i$ (8)

$\lambda_j \; \geq 0, \forall j$

$\sum_{j=1}^{n} \lambda_j \; = 1$ (9)

Banker et al. (1984), DEA-BCC-model remove the constraint from the CCR-model by adding $\sum_{i=1}^{n} \lambda_i \; = 1$ thus, BCC is able to distingush between technical and scale inefficiencies by (i) estimating pure technical efficiency at the given scale of operation (ii) identifying whether increasing, decreasing or constant return to scale possibilities are present for further exploitation. The measure of efficiency provided by BCC model is known as pure technical efficiency (PTE) and denoted as $\emptyset \; BCCo$. The ratio $(\emptyset CCRo \,/\, \emptyset BCCo \;)$ provides a measure of scale efficiency (SE). Note that all aforementioned efficiency measures are bound between one and zero. The measure of scale efficiency (SE) does not indicate whether the DMU in question is operating in the area of increasing or decreasing returns-to-scale. The nature of returns-to-scale can be determined from the magnitude of optimal (Kumar & Gulati, 2008).

$(\sum_{j=1}^{n} \lambda_j^*)$In the CCR model (Banker, 1984). Seiford & Zhu (1999) listed following three cases:

i) If $(\sum_{j=1}^{n} \lambda_j^* = 1)$ in any alternate optima, then CRS prevail on DMU_o; (10)

ii) If $(\sum_{j=1}^{n} \lambda_j^* < 1)$ in any alternate optima, then IRS prevail on DMU_o; and(11)

iii)If $(\sum_{j=1}^{n} \lambda_j^* > 1)$in any alternate optima, then DRS prevail on DMU_o. (12)

The CCR and BCC models need to be solved n times, once for each DMU to obtain the optimal values for $\emptyset_o, \; \lambda_1 \,, \; \lambda_2 \,, \ldots, \lambda_{1n} s_i^-, s_r^+ \; (i.e. \emptyset_o^*, \lambda_1^*, \lambda_2^*, \ldots, \lambda_n^*, s_i^{-*}, s_r^{+*})$.The interpretation of the results of above models can be summarized as:

a) If $\emptyset_o^* \; = 1$, then DMU under evaluation is a frontier point, i.e., there is no other DMUs that are operating more efficiently than this DMU. Otherwise, if $\emptyset_o^* < 1$, then the DMU under evaluation is inefficient, i.e., this DMU can either increase its output levels or decrease its input levels.

b) The left-hand side of the constraints ii) and iii) is called the 'Reference Set', and the right-hand side represents a specific DMU under evaluation. The non-zero optimal λ^*_j represents the benchmarks for a specific DMU under evaluation. The Reference Set provides coefficients (λ^*_j) to define hypothetical efficient DMU.

c) The efficient targets for inputs and outputs can be obtained as $\hat{x_{io}} = \emptyset_o^* x_{i0} \; - \; s_i^{-*} and \; \hat{y_{ro}} \; = \; y_{r0} \; + s_r^{+*}$, respectively. Theseefficiency targets show how inputs can be decreased and outputs increased to make the DMU under evaluation efficient.

Where $y_i = (y_{1i}, y_{2i}, \ldots \ldots \ldots, y_{Ri})$ is the output vector, $x_i = (x_{1i}, x_{2i}, \ldots \ldots \ldots, x_{Si})$ is the input vector,λ *is a* $1x1$ vector constants. Solving the equation for each one of the n airports of the sample size, n weight and n optimal solution found in the linear programming problem. Each optimal solution $\emptyset_j^*$ is the efficiency indicator of the airports j and , by construction it satisfies $\emptyset^*_j \leq 1$. These airports with $\emptyset^*_j < 1$ are considered inefficient and airports with $\emptyset^*_j = 1$ are efficient. Where the symbol " $*$ "denotes an optimal value. It is known as variable return to scale (VRS). Banker et al (1996a) approach insures that the return-to-scale analyses are conducted on the efficiency frontier. Finally for CCR-model efficient is required both scale and technical efficient while BCC-model efficient is only required technically efficiency.

2.0 Data

Secondary data were used in the analysis to produce the results. The Federal Airport Authority of Nigeria (FAAN), the Central Bank of Nigeria (CBN), the Nigeria Airspace Management Agency (NAMA), the Nigeria Civil Aviation Authority (NCAA), and the Nigeria Bureau of Statistics were the sources of the data. Passenger throughput, aircraft movement, employee count, total assets, total cost, and terminal capacity are the metrics that were gathered. Passenger throughput and aircraft movement served as the analysis' output variables, while terminal capacity, employee count, total assets, and overall cost served as the study's input factors. Amino Kano Domestic Airport (KAN DOM), Amino Kano International Airport (KAN INT'L), Murtala Muhammed Domestic Airport (MMA DOM), Murtala Muhammed International Airport (MMA INT'L), Port Harcourt Domestic Airport (PHC DOM), and Port Harcourt International Airport (PHC INT'L) are the airports chosen.

Table 4.2 Correlation Analysis Result

	Terminal capacity	Employees	Total assets	Total cost	Passengers	Aircraft
Termina lcapacity	1	0.57968	0.123342488	-0.0631713	0.23569	0.04012
Employees	0.57968	1	0.498251194	0.234766798	0.72127	0.61056
Total assets	0.12334	0.49825	1	0.300235604	0.28605	0.19419
Total cost	-0.0632	0.23477	0.300235604	1	0.08463	0.05959
Passengers	0.23569	0.72127	0.286050883	0.084629691	1	0.92722
Aircraft	0.04012	0.61056	0.194193176	0.059589646	0.92722	1

4.1.1 Correlation Matrix Analysis

It is justifiable to include the outputs in the model since the correlation analyses show substantial positive correlations between the inputs and outputs, making them isotonic (Marques and Simoes, 2010). The correlation study for thirty airports in Nigeria reveals a number of meaningful connections between the inputs and outputs of the simplest DEA analysis. The relationship between terminal capacity, employee count, total assets, total cost, and passenger throughputs may be seen in table 4.2 below. The value of 72% for the number of employees indicates a stronger correlation between input and output. In terms of the link between the number of employees and the passengers, this indicates that there are many employees working at the terminal who are able to handle the services. The relationships between the other inputs and the output variables are much weaker. According to the results of the correlation analysis, there is a 61% correlation between the number of employees and aircraft movements, indicating a strong and significant relationship between the input and output. While the relationships between the other inputs and the outputs are highly shaky. Finally, the correlation analysis shows that relatively few input and output variables have stronger significant relationships.

2.1 Analysis of Production Function and Return to Scale of the Selected Airports in Nigeria

Table 4.3 BCC Efficiency Score and Return to Scale Projected Decision-Making Units

Year	No.	DMU	Score	RTS of Projected DMU
2003	ABJ DOM	ABJ DOM	0.8062	Increasing
	ABJ INT'L	ABJ INT'L	0.9719	Constant
	KAN DOM	KAN DOM	1	Increasing
	KAN INT'L	KAN INT'L	0.7504	Increasing
	MMA DOM	MMA DOM	0.7039	Constant
	MMA INT'L	MMA INT'L	0.4728	Constant
	PHC DOM	PHC DOM	1	Constant
	PHC INT'L	PHC INT'L	0.9995	Increasing
2004	ABJ DOM	ABJ DOM	1	Constant
	ABJ INT'L	ABJ INT'L	0.9719	Constant
	KAN DOM	KAN DOM	1	Increasing
	KAN INT'L	KAN INT'L	0.7504	Increasing
	MMA DOM	MMA DOM	0.8633	Constant
	MMA INT'L	MMA INT'L	0.3011	Constant
	PHC DOM	PHC DOM	0.766	Increasing
	PHC INT'L	PHC INT'L	0.9899	Increasing
2005	ABJ DOM	ABJ DOM	0.8756	Increasing
	ABJ INT'L	ABJ INT'L	0.7465	Constant
	KAN DOM	KAN DOM	1	Increasing
	KAN INT'L	KAN INT'L	0.7533	Increasing

	MMA DOM	MMA DOM	0.8046	Constant
	MMA INT'L	MMA INT'L	0.5328	Constant
	PHC DOM	PHC DOM	0.9629	Increasing
	PHC INT'L	PHC INT'L	1	Constant
2006	ABJ DOM	ABJ DOM	0.6466	Increasing
	ABJ INT'L	ABJ INT'L	0.7435	Constant
	KAN DOM	KAN DOM	1	Increasing
	KAN INT'L	KAN INT'L	0.7237	Increasing
	MMA DOM	MMA DOM	0.89	Constant
	MMA INT'L	MMA INT'L	0.6082	Constant
	PHC DOM	PHC DOM	0.9439	Increasing
	PHC INT'L	PHC INT'L	1	Increasing
2007	ABJ DOM	ABJ DOM	0.8932	Increasing
	ABJ INT'L	ABJ INT'L	0.7435	Constant
	KAN DOM	KAN DOM	0.9635	Increasing
	KAN INT'L	KAN INT'L	0.7128	Increasing
	MMA DOM	MMA DOM	0.7563	Decreasing
	MMA INT'L	MMA INT'L	0.6881	Constant
	PHC DOM	PHC DOM	0.9386	Constant
	PHC INT'L	PHC INT'L	1	Increasing
2008	ABJ DOM	ABJ DOM	0.9389	Increasing
	ABJ INT'L	ABJ INT'L	0.7435	Constant
	KAN DOM	KAN DOM	0.9658	Increasing
	KAN INT'L	KAN INT'L	0.722	Increasing
	MMA DOM	MMA DOM	0.6985	Decreasing
	MMA INT'L	MMA INT'L	0.7211	Constant
	PHC DOM	PHC DOM	0.9366	Constant
	PHC INT'L	PHC INT'L	1	Increasing
2009	ABJ DOM	ABJ DOM	0.966	Increasing
	ABJ INT'L	ABJ INT'L	0.7435	Constant
	KAN DOM	KAN DOM	0.9733	Increasing
	KAN INT'L	KAN INT'L	0.7216	Increasing
	MMA DOM	MMA DOM	0.7822	Decreasing
	MMA INT'L	MMA INT'L	0.7164	Constant
	PHC DOM	PHC DOM	0.9411	Increasing
	PHC INT'L	PHC INT'L	1	Increasing
2010	ABJ DOM	ABJ DOM	1	Increasing
	ABJ INT'L	ABJ INT'L	0.7386	Constant
	KAN DOM	KAN DOM	1	Increasing
	KAN INT'L	KAN INT'L	0.7217	Increasing
	MMA DOM	MMA DOM	0.9676	Decreasing
	MMA INT'L	MMA INT'L	0.7416	Constant

	PHC DOM	PHC DOM	0.9626	Constant
	PHC INT'L	PHC INT'L	0.9994	Increasing
2011	ABJ DOM	ABJ DOM	1	Constant
	ABJ INT'L	ABJ INT'L	0.7148	Constant
	KAN DOM	KAN DOM	1	Constant
	KAN INT'L	KAN INT'L	0.7077	Increasing
	MMA DOM	MMA DOM	1	Decreasing
	MMA INT'L	MMA INT'L	0.7828	Constant
	PHC DOM	PHC DOM	0.9267	Increasing
	PHC INT'L	PHC INT'L	0.9883	Increasing
2012	ABJ DOM	ABJ DOM	0.8999	Increasing
	ABJ INT'L	ABJ INT'L	0.6958	Constant
	KAN DOM	KAN DOM	0.9943	Increasing
	KAN INT'L	KAN INT'L	0.696	Increasing
	MMA DOM	MMA DOM	1	Decreasing
	MMA INT'L	MMA INT'L	0.8709	Constant
	PHC DOM	PHC DOM	0.9135	Increasing
	PHC INT'L	PHC INT'L	1	Increasing
2013	ABJ DOM	ABJ DOM	1	Constant
	ABJ INT'L	ABJ INT'L	0.6774	Constant
	KAN DOM	KAN DOM	0.9939	Increasing
	KAN INT'L	KAN INT'L	0.6847	Increasing
	MMA DOM	MMA DOM	1	Decreasing
	MMA INT'L	MMA INT'L	1	Constant
	PHC DOM	PHC DOM	0.9368	Constant
	PHC INT'L	PHC INT'L	0.9494	Increasing
2014	ABJ DOM	ABJ DOM	0.9305	Constant
	ABJ INT'L	ABJ INT'L	0.6774	Constant
	KAN DOM	KAD INT'L	0.9234	Increasing
	KAN INT'L	KAN DOM	0.6982	Increasing
	MMA DOM	MMA DOM	1	Decreasing
	MMA INT'L	MMA INT'L	0.9479	Decreasing
	PHC DOM	PHC DOM	1	Constant
	PHC INT'L	PHC INT'L	1	Constant
2015	ABJ DOM	ABJ DOM	1	Constant
	ABJ INT'L	ABJ INT'L	0.7081	Constant
	KAN DOM	KAN DOM	0.8989	Increasing
	KAN INT'L	KAN INT'L	0.6993	Increasing
	MMA DOM	MMA DOM	0.9929	Decreasing
	MMA INT'L	MMA INT'L	0.3122	Constant
	PHC DOM	PHC DOM	1	Constant
	PHC INT'L	PHC INT'L	0.987	Increasing

Average	0.8576		
Max	1		
Min	0.3011		
St Dev	0.1547		

No. of Increasing RTS=50

No. of Constant RTS=44

No. of Decreasing RTS=10

The type of returns-to-scale for each airport during the study period is shown in Table 4.3 above.

The findings show that 26 airports, which were operating at their most productive scale size from 2003 to 2015, are efficient (i.e., 100%). The airports are (in 2003: KAN DOM; ABJ DOM; PHC DOM; in 2004: ABJ DOM, KAN DOM; in 2005: KAN DOM, PHC INT'L; in 2006: PHC INT'L; in 2007: PHC INT'L; in 2008: PHC INT'L. while the other airports in the survey had become inefficient over time The smallest efficiency scale is 0.3011, while the average efficiency scale for airports is 0.8576. Consequently, on average, no airport in Nigeria meets the International Civil Aviation Authority's (ICAO) criteria of 100% operational efficiency. Since the average efficiency score of 0.85761 over the course of the 14-year study, the 8 airports that were examined demonstrate that no airport runs at a maximum efficiency level (i.e., at an optimal scale of relative efficiency). The study's findings concur with those of an earlier investigation into the appraisal of regional airports in Nigeria by Ogwude, Nwaogbe, Pius, Idoko, and Ejem (2018). The analysis's findings are displayed in Table 4.3 above for the airports that operate under constant return to scale and variable return to scale.

According to the table, during the study period, 50 airports operated under an increasing return to scale, 44 under a steady return to scale, and 10 under a falling return to scale. This demonstrates that the eight chosen airports were examined over a 14-year period. It also demonstrates whether the airports' returns to scale were constant or fluctuating during that time. The outcome demonstrates the economies of scale of these airports over the course of the study and the performance of the airports. As a result, the federal government can evaluate the airports and receive complete guidance regarding their privatization or consolidation.

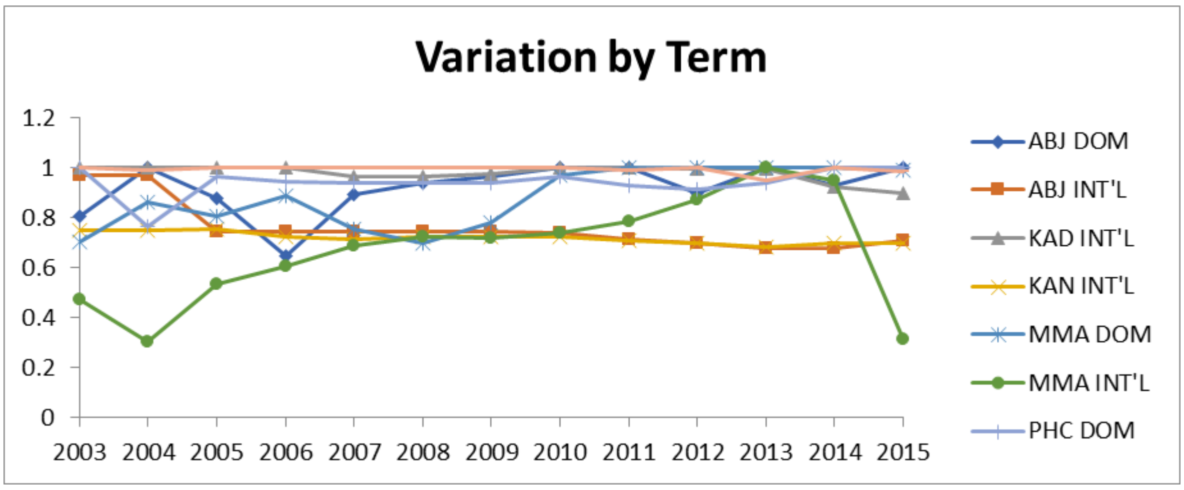

Figure 4.3 Variation of Efficiency Scores by Term of the Constant Return to Scale Graph

More so, the window analysis variation graph shows that about 27 airports were efficient based on a yearly examination of the analysis. The result of the window analysis corresponds to the analysis of the BCC-model (variable return to scale) of the DEA model. The results show that from 2003 to 2015, those airports had a line graph pointing to one, indicating that they were operating at peak technical efficiency. Therefore, those airports should be used as a benchmark for the airports that are operating below an efficiency score of 1, as shown in the graph above**.**

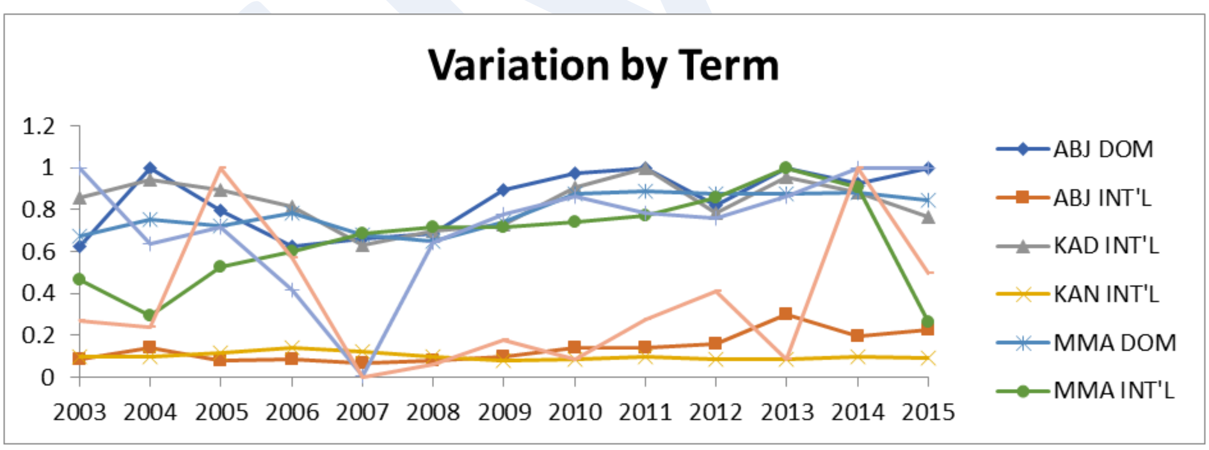

Figure 4.3 Variation of Efficiency Scores by Term of the Constant Return to Scale Graph

From the line graph in Figure 4.2 above, it shows the fluctuation of the efficiency score of the eight airports studied from 2003 to 2015. The graph shows that the line that points at score 1 is efficient, while those below it are inefficient airports. Furthermore, the results show that eight airports were efficient in different years based on the yearly and efficiency line graphs plotted during the study's window analysis.

Table 4.4 Window Analysis of 8 Nigerian Airports for Variable Return to Scale

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average	C-Average
ABJ DOM	0.806	1	0.876	0.647	0.893	0.9389	0.966	1	1	0.9	1	0.9305	1	0.9198	0.9198
ABJ INT'L	0.972	0.972	0.747	0.743	0.743	0.7435	0.743	0.739	0.715	0.696	0.677	0.6774	0.7081	0.7597	0.7597
KAD INT'L	1	1	1	1	0.964	0.9658	0.973	1	1	0.994	0.994	0.9234	0.8989	0.9779	0.9779
KAN INT'L	0.75	0.75	0.753	0.724	0.713	0.722	0.722	0.722	0.708	0.696	0.685	0.6982	0.6993	0.7186	0.7186
MMA DOM	0.704	0.863	0.805	0.89	0.756	0.6985	0.782	0.968	1	1	1	1	0.9929	0.8815	0.8815
MMA INT'L	0.473	0.301	0.533	0.608	0.688	0.7211	0.716	0.742	0.783	0.871	1	0.9479	0.3122	0.6689	0.6689
PHC DOM	1	0.766	0.963	0.944	0.939	0.9366	0.941	0.963	0.927	0.913	0.937	1	1	0.9407	0.9407
PHC INT'L	1	0.99	1	1	1	1	1	0.999	0.988	1	0.949	1	0.987	0.9933	0.9933
Average	0.838	0.83	0.834	0.819	0.837	0.8408	0.856	0.891	0.89	0.884	0.905	0.8972	0.8248		

2.3 Window Analysis

The window analysis in Table 4.4 above demonstrates that the result of pure technical efficiency is robust because it takes variable return to scale into account. The result shows that 27 airports were efficient based on a yearly analysis of the window result of the variable return to scale. Airports with an efficiency score of one are efficiency airports, while those with a score less than one are inefficient airports.

Table 4.5 Window Analysis of 8 Nigerian Airports for Constant Return to Scale

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average	C-Average
ABJ DOM	0.626	1	0.795	0.625	0.661	0.6876	0.892	0.973	1	0.82	1	0.926	1	0.8465	0.8465
ABJ INT'L	0.087	0.14	0.082	0.084	0.067	0.0817	0.1	0.141	0.141	0.162	0.3	0.1974	0.2272	0.1392	0.1392
KAD INT'L	0.856	0.945	0.896	0.814	0.634	0.6963	0.732	0.904	1	0.787	0.957	0.8853	0.7656	0.8364	0.8364
KAN INT'L	0.095	0.098	0.117	0.144	0.122	0.0989	0.079	0.087	0.099	0.088	0.088	0.0996	0.0926	0.1006	0.1006
MMA DOM	0.672	0.755	0.725	0.783	0.678	0.6524	0.742	0.874	0.892	0.876	0.879	0.8811	0.846	0.7889	0.7889
MMA INT'L	0.468	0.292	0.529	0.603	0.687	0.7196	0.716	0.741	0.772	0.859	1	0.9042	0.2621	0.6579	0.6579
PHC DOM	1	0.635	0.715	0.419	0.004	0.6427	0.781	0.867	0.783	0.76	0.867	1	1	0.7287	0.7287
PHC INT'L	0.272	0.236	1	0.568	0	0.0603	0.18	0.088	0.278	0.411	0.084	1	0.4936	0.3593	0.3593
Average	0.509	0.513	0.607	0.505	0.357	0.4549	0.528	0.584	0.62	0.596	0.647	0.7367	0.5859		

Furthermore, the window analysis result in Table 4.5 corresponds to the DEA analysis's CCR-model result. The result shows that eight airports in different years were operating at an efficiency score of 1, meaning that those airports were efficient in terms of their operational performance in those years, while those below an efficiency score of 1 were operating at an inefficient level. Therefore, there is a need to use the airports in the years they are efficient to benchmark the ones that are not efficient to get the best standard that will meet the ICAO standard.

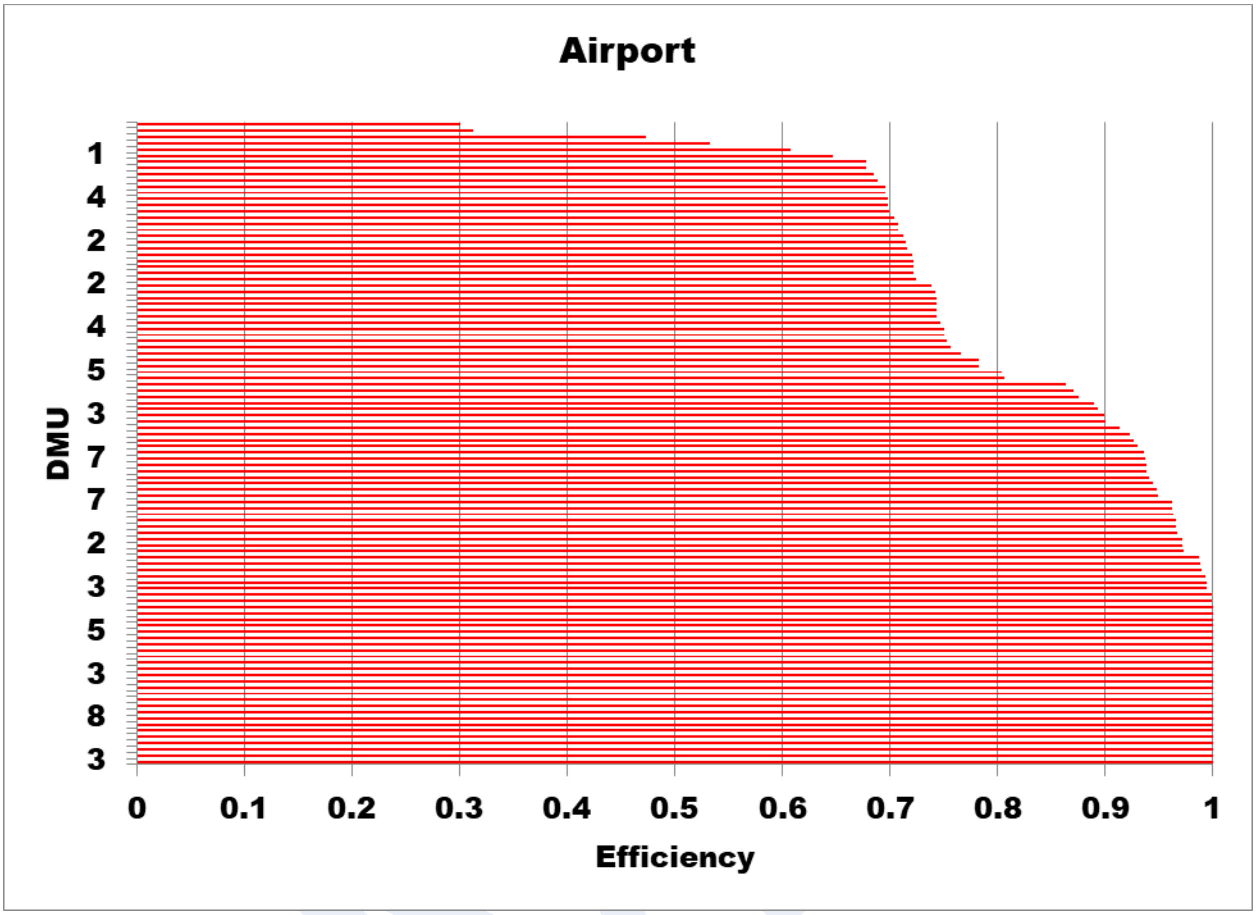

Figure 4.4 Efficiency Score Graph of BCC Analysis

The figure 4.4 graph shows the efficiency score results of the twenty-six significant airports that are on the production frontier. The airports that reach 100% efficiency, or a score of 1, mean that the airports are operating on pure technical efficiency. The airports are as follows: (in 2003: KAN DOM; ABJ DOM, PHC DOM; 2004: ABJ DOM, KAN DOM; 2005: KAN DOM, PHC INT'L; 2006: PHC INT'L; 2007: PHC INT'L; 2008: PHC INT'L; 2009: PHC INT'L; 2010: ABJ DOM, KAN DOM; 2011: ABJ DOM, KAN While the other DMUs (airports), as shown in the graph in figure 4.4 above, are explained in the order of the efficiency ranking (level of efficiency of the airports) based on the BCC-model result analysis.

Table 4.6Projection/ Forecast of the Inputs and Output variables (Independent and Dependent Variables) of the selected Airports

	Terminal capacity			Employees			Total assets			Totalcost			Passengers			Aircraft		
	Data	Projection	Diff.(%)	Data	Projection	Diff.(%)	Data	Projection	Diff.(%)	Data	Projection	Diff.(%)	Data	Projection	Diff.(%)	Data	Projection	Diff.(%)
Average	942	605	19	682	547	15	1.92E+10	8E+09	30	1E+09	6.2E+08	29	1236692	1466838	246.94	20998	29530	476
Max	3675	3675	86	1430	1390	85	1.50E+11	4E+10	97	2E+10	2.8E+09	97	4389241	4389241	17677	81680	81680	28195
Min	148	148	0	210	210	0	39868207	4E+07	0	2E+07	1.7E+07	0	0	0	0	0	0	0
St Dev	1076	532	23	353	277	16	2.47E+10	9E+09	32	2E+09	6.1E+08	32	1295380	1243691	1732.4	22548	21070	2768

From table 4.6 above, the result of the analysis shows the average projection of the input and output data used for the analysis. With regard to inputs, the descriptive statistics of the model projection show the average of the overall projection and the differences (%) of the terminal capacity, number of employees, total cost, and total assets as the inputs, then passenger output and aircraft movement projection as the case may be. The projection shows the differences between the actual data used for the analysis and what needs to be added in order to get an efficient result and productive operation of the airports. Therefore, if the study is really used for policy implications, it is going to be of great importance for the aviation industry.

2.4 Production Function Analysis of CCR-Model

Table 4.7 Production function Analysis using CCR. Model of DEA

DMU	Score	Rank
PHC DOM	1	1
ABJ DOM	1	1
PHC INT'L	1	1
ABJ DOM	1	1
KAN DOM	1	1

ABJ DOM	1	1
MMA INT'L	1	1
PHC DOM	1	1
PHC INT'L	1	1
ABJ DOM	1	1
PHC DOM	1	1
ABJ DOM	0.9735	12
KAN DOM	0.9575	13
KAN DOM	0.9451	14
ABJ DOM	0.926	15
MMA INT'L	0.9042	16
KAN INT'L	0.9041	17
KAN INT'L	0.896	18
ABJ DOM	0.8917	19
MMA DOM	0.8915	20
KAN DOM	0.8853	21
MMA DOM	0.8811	22
MMA DOM	0.8786	23
MMA DOM	0.8763	24
MMA DOM	0.874	25
PHC DOM	0.8666	26
PHC DOM	0.8666	26
MMA INT'L	0.8592	28
KAN DOM	0.8556	29
MMA DOM	0.846	30
ABJ DOM	0.8195	31
KAN DOM	0.8141	32
ABJ DOM	0.7949	33
KAN DOM	0.7873	34
MMA DOM	0.7833	35
PHC DOM	0.7826	36
PHC DOM	0.781	37
MMA INT'L	0.7715	38
KAN DOM	0.7656	39
PHC DOM	0.7602	40
MMA DOM	0.7552	41
MMA DOM	0.7416	42
MMA INT'L	0.7413	43
KAN DOM	0.7323	44
MMA DOM	0.7253	45
MMA INT'L	0.7196	46
MMA INT'L	0.7158	47

PHC DOM	0.7151	48
KAN DOM	0.6963	49
ABJ DOM	0.6876	50
MMA INT'L	0.6872	51
MMA DOM	0.6783	52
MMA DOM	0.6722	53
ABJ DOM	0.6613	54
MMA DOM	0.6524	55
PHC DOM	0.6427	56
PHC DOM	0.635	57
KAN DOM	0.634	58
ABJ DOM	0.6255	59
ABJ DOM	0.6246	60
MMA INT'L	0.6031	61
PHC INT'L	0.5678	62
MMA INT'L	0.5293	63
PHC INT'L	0.4936	64
MMA INT'L	0.4675	65
PHC DOM	0.4191	66
PHC INT'L	0.4109	67
ABJ INT'L	0.3004	68
MMA INT'L	0.2919	69
PHC INT'L	0.2775	70
PHC INT'L	0.2724	71
MMA INT'L	0.2621	72
PHC INT'L	0.2365	73
ABJ INT'L	0.2272	74
ABJ INT'L	0.1974	75
PHC INT'L	0.1804	76
ABJ INT'L	0.1623	77
KAN INT'L	0.1437	78
ABJ INT'L	0.141	79
ABJ INT'L	0.1406	80
ABJ INT'L	0.14	81
KAN INT'L	0.1219	82
KAN INT'L	0.1169	83
ABJ INT'L	0.1001	84
KAN INT'L	0.0996	85
KAN INT'L	0.0989	86
KAN INT'L	0.0989	86
4 KAN INT'L	0.0984	88
KAN INT'L	0.0953	89

KAN INT'L	0.0926	90
KAN INT'L	0.0884	91
PHC INT'L	0.0879	92
KAN INT'L	0.0876	93
KAN INT'L	0.0866	94
ABJ INT'L	0.0865	95
PHC INT'L	0.0841	96
ABJ INT'L	0.0837	97
ABJ INT'L	0.0818	98
ABJ INT'L	0.0817	99
KAN INT'L	0.0794	100
ABJ INT'L	0.0667	101
PHC INT'L	0.0603	102
PHC DOM	0.0042	103
PHC INT'L	0.0002	104
Average	0.5572	
Max	1	
Min	0.0002	
St Dev	0.3441	

Table 4.7 shows the estimation of efficiency scores using the CCR-model. Various evaluation categories of the DMUs' ownership and governance, including the technical efficiency (i.e., CRS efficiency), the pure technical efficiency (i.e., VRS efficiency), the scale efficiency, and the returns to scale, need to be examined when analyzing the operating efficiency of airports. The CCR model can be used to determine technical efficiency, and the BCC model can be used to determine pure technical efficiency when analyzing the productivity and efficiency of Nigerian airports using the DEA model. Lai (2013) claims that in order to calculate scale efficiency, technical efficiency is divided by pure technical efficiency. The operating efficiency of each airport is then examined using the obtained efficiency values. Furthermore, Coelli et al. (2005) introduced the idea that a DEA-CCR model assumes that every DMU is working at its optimal scale. To satisfy the organizational and governmental goals for setting up the airports, however, the airports may not operate at an ideal scale due to imperfect competition, government laws, financial limits, and a lack of suitable infrastructure.

The CCR-model results show efficiency based on the analysis. Scores for the thirty airports in Nigeria are shown in Table 4.7 above. The efficiency indices ranged from 0.0002 to 1 for the CCR-model result. The result shows that at least 11 different airports are considered to be technically efficient based on the CCR-model analysis result. Furthermore, when analyzing the CCR-model, it was observed that the model is interested in constant return to scale, and its efficiency score (1) result shows that eleven (DMU) airports were efficient from 2003 to 2015, which is about 14 years. The DMUs (airports) are PHC DOM, ABJ DOM, PHC INT'L, ABJ DOM, KAN DOM, ABJ DOM, MMA INT'L, PHC DOM, PHC INT'L, ABJ DOM, and PHC DOM. These airport efficiency scale results range from 2003 to 2015 and represent the results of several years.

These airports are effective, with a maximum efficiency value of 1.0. According to Table 4.7 above, airports with efficiencies of less than 1 or less than 100% are inefficient. According to Sengupta (1995), average efficiencies can be used to assess industrial competitiveness. The CCR-8 model's DMUs have an average efficiency of 0.5572 (56%). This indicates that, depending on the significance or quantity of the data set, a link between the input and output values exists. This indicates that, depending on the significance or quantity of the data set, a link between the input and output values exists. The reason for this inefficiency may be that certain airports were chosen for fewer air carriers, as well as low airport infrastructure and a low standard of airline aircraft maintenance, which results in numerous aircraft accidents at airports. Additionally, that can lead some airlines to relocate their operations to nearby airports or airports in neighboring countries (Nwaogbe et al., 2017).

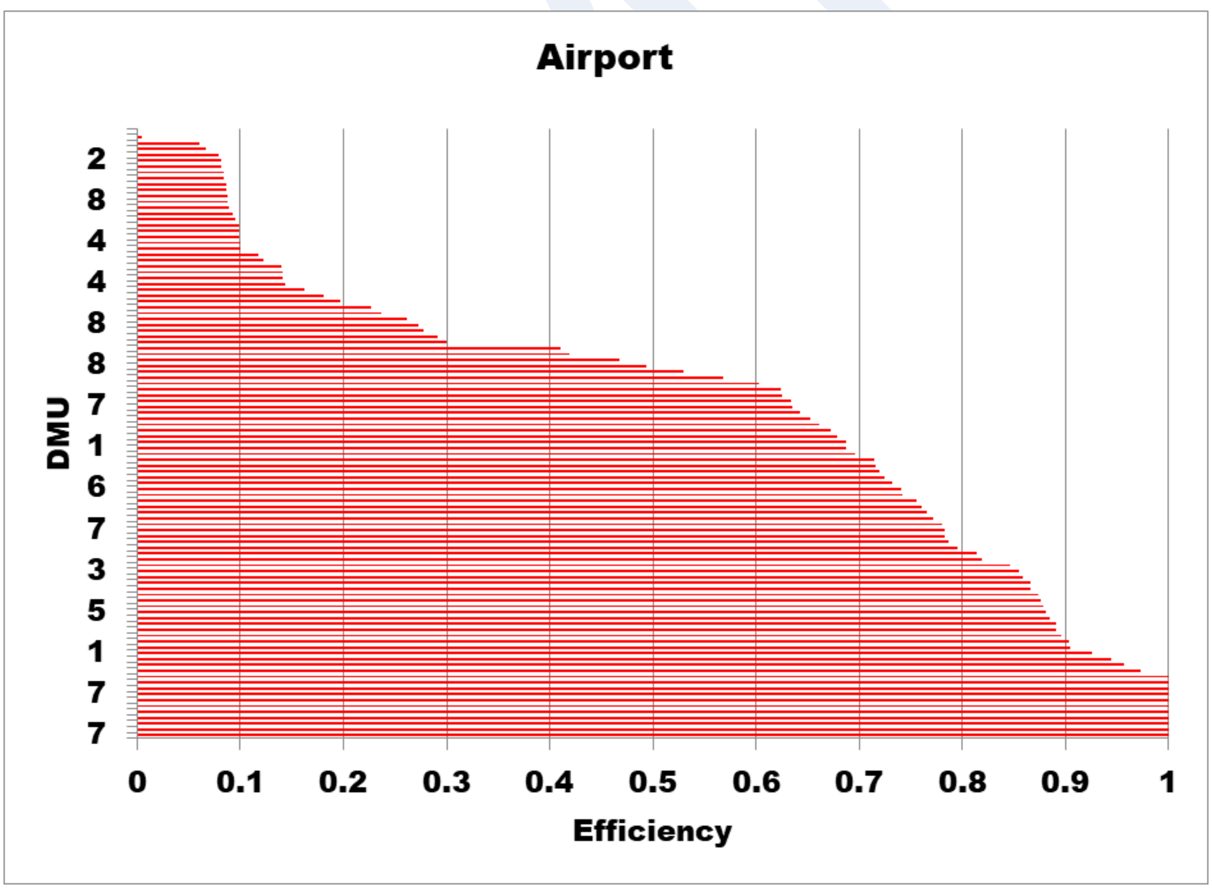

Figure 4.5 CCR Efficiency Graph

Scientifically, the production function efficiency ratings are displayed on the graph in Figure 4.5. It displays a graph of the airport production frontier. The airports on the frontier graph are those that have an efficiency score of 1 or are operating at 100% efficiency. PHC DOM, PHC INT'L, ABJ DOM, KAN DOM, MMA INT'L, PHC DOM, PHC DOM, PHC INT'L, ABJ DOM, and PHC DOM FROM 2003 TO 2015 are the airports. The outcome was produced by the CCR-model, which took into account the continuous return to scale of input and output variables. Since these eight airports are on the frontier, they are performing at a high level of efficiency. Airport inefficiency is below the frontier, though.

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3.0 Conclusion

The purpose of this study is to calculate the production function of a few chosen airports in Nigeria. The study concentrated on eight particular airports in Nigeria's north, west, and south. The study findings reveal the airports that are working at a 100% efficiency level (1) as well as the airports that are running with an increasing, declining, or steady return to scale. Eight airports were operating at 100% efficiency within the 14 years of the study period, according to the constant return to scale model (CCR-Model), based on the fundamental DEA model used for the analysis. While the Variable Return to Scale model (BCC-Model) indicates that during the 14-year study period, there were 26 airports operating at a 100% efficiency level, this indicates that of the eight airports, at least one or two operate at a high degree of efficiency each year. Additionally, window analysis was carried out with the aid of the DEA software, and the results are comparable to those of the basic DEA models (CCR-Model and BCC-Model), indicating that the basic DEA result was quite similar to that of window analysis. These results highlight the top eight airports out of the eight that were examined during the course of the 14-year study period. The analysis's findings highlight an effective airport that can be used to measure other airports' efficiency during the study period. The study suggests that the federal government use the study as a tool to determine which airports should be privatized as part of the privatization process. Based on projections about how to handle inefficient airports, policy implications were drawn.

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