RESEARCH ARTICLE

AN EMPIRICAL INVESTIGATION INTO THE TECHNICAL EFFICIENCY OF PUBLIC UNIVERSITIES IN NIGERIA THROUGH A NON-PARAMETRIC TECHNIQUE

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ARTICLE INFO	ABSTRACT
	Nigeria's Public universities massively depend on government funding to run their affairs. However, the funding continuously becomes scarcer as the universities continuously growing in relation to student enrolments and establishments of new departments and faculties. It becomes a concern to the government about how these universities utilise their resources and do their goals really delivered as expected? Therefore, this paper uses the prevailing non-parametric technique (DEA) mostly used for efficiency analysis of public institutions with multiple inputs and outputs (example, universities) to investigate the technical efficiency of Nigerian public universities from 2007/2008 to 2011/2012. The result shows that 2 universities out of the total of 18 are found to be technically efficient for the whole 5 years observed while 6 universities have never been efficient in any of the 5 years. Policy recommendation is given to the government for making the efficiency index as a yardstick toward fund allocation, hence, this encourages a favourable competition among the universities to be efficient enough in discharging their duties of teaching and research as expected.

INTRODUCTION

In today's world, there is no any institution which is regarded as the apex centre for creating and imposing knowledge like the universities.Teaching and research are the major leading activities of every university which can lead to economic growth and development of a nation. Nigerian public universities in recent years have been receiving large number of applicants to secure a place in any of the faculties for study and the universities keep on growing in terms of number of students' intake and new faculties and department creation. However, public funding of the universities continuously become scarce considering other competitive recipients of public fund like the healthcare, security and social welfare is also increasing. Regarding the significance of university education, Ajayi and Ekundayo (2006) explain that the funds allocated to institutions of higher learning should not be simply considered as cost expenses, rather long-term investments, which benefit the whole society in general. However, Banya and Elu (2001) explain that on average, higher education in Sub-Saharan Africa consumes a share of total resources 25 times greater than in developed countries, almost 15 times greater than the total in Latin American countries and 10 times greater than in Asian countries.

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For that reason, the Nigerian public universities have to be efficient enough, even though they might have insufficient funding, lower allocations and other internal challenges but that would not prevent them to utilise all their limited resources efficiently and effectively in achieving their major goals and objectives. Therefore, in order to have some improvements these Nigerian public universities' efficiency, a tool has to be created toward measuring their performance so that the government as a policy maker can make decisions on the appropriate mechanism to allocate fund for long term planning. Even though the measurement of public institutions' efficiency, example, universities is difficult because they are non-profit oriented in which input and output prices are not ascertained. Johnes (2006a) also opines that the institutions of higher learning in general have multiple inputs and outputs. On that note, Data Envelopment Analysis (DEA) is to be used because one of the major conditions of using the DEA is presence of multiple inputs and outputs which the subject of concern in this research, which is universities also have multiple inputs and outputs. DEA is a non-parametric technique which is broadly accepted in measuring the relative efficiency of a group of homogeneous institutions or oragnisations that utilise multiple inputs in producing multiple outputs. The homogeneous institutions or organisations are called Decision Making Units (DMUs). Therefore, this paper uses DEA to investigate the relative efficiency of 18 public universities in Nigeria from 2007/2008 to 2011/2012 academic sessions.

NIGERIAN UNIVERSITY SYSTEM

Nigeria is the most populated country in Africa where on average 50% of the population are urban dwellers. The 2006 National Population and Housing Census estimated Nigeria's population at 140,431,790 people with a projection of 149,525,821 in 2008, 159,538,079 in 2010 and 174,507,539 in 2013 (*Annual Abstract of Statistics*, 2012). Christian missionaries first brought the western (formal) system of education into Nigeria within nineteenth century. Education is currently in the concurrent list of Nigeria's constitution where the responsibility of creating and funding is shared by the Nigerian federal, state, and local governments. However, higher education is strictly for federal and state governments and massively funded by the government, though private owned higher education institutions are also allowed. Ekundayo and Ajayi (2009) explain that base on the Nigeria's National Policy on Education 2004, institutions of higher learning are purposely required to teach and train the teeming populace and conduct research for growth and development of Nigeria. Higher education institution in Nigeria comprises the universities for award of Degree and Postgraduate Degree; polytechnics for technical Diploma and Higher National Diploma; monotechnics for technical Certificate and Diploma; and colleges of education for awards of National Certificate of Education.

Nigerian universities are mostly government owned (federal or state government) and largely funded by the government. Thus, they are constitutionally referred as public universities and have the largest student intake yearly due to their affordability in term of cost. In general, public universities in Nigeria have negligible internal funds because they are based on tuition-free to national students. The organisational hierarchy of universities in Nigeria, at the top management is the Vice Chancellor (VC) and two Deputy Vice Chancellors (DVCs) for academic issues and administrative issues. The universities are structured by faculties headed by Deans and one assistant, while the faculties are in turn subdivided into departments headed by Head of Department (HODs); the departments which have main responsibility for the planning and implementation of educational and academic programmes. Student places in Nigerian public universities are secured yearly with a rigorous and competitive national examination called Unified Tertiary Matriculation Examination (UTME) and obtain at least 180 points out of 400 depending on the candidate's field of study. However, that depends on the candidate's secondary school result called Secondary School Certificate Examination (SSCE) which must pass at least five subjects including Mathematics, English Language and any other three subjects related to the candidate's field. The universities finally screen and decide who to secure a place based on the universities' individual criteria. Additionally, for post graduate studies, places are secured based on a very good Bachelor Degree for Masters and very good Master Degree for PhDs. The remaining part of this paper is categorised into the following sections: section 3 presents literature review of recent and relevant studies in higher education efficiency; section 4 of the paper presents methodology and data presentation where the inputs and outputs used in the study are defined; section 5 is the results presentation and overall discussion; section 6 conclude the paper with concluding remarks and policy recommendation, as well as future research recommendation.

LITERATURE REVIEW

The literature review is sub-divided into two: studies about universities' efficiencies with DEA in general; studies on public university efficiencies. However, some of the studies make cross country analysis in Europe, example, Agasisti and Johnes (2009) look into universities in England and Italy where universities in England are found to be more efficient, but Italian universities have an increasing efficiency rate more than those in England. Izadi *et al.* (2002) investigate 209 universities through 8 European countries while Wolszczak-Derlacz and Partera (2011) examine 259 public universities across Australia, Switzerland, Finland, Italy, UK, Germany and Poland from 2001 to 2005 and reveal that only 5% of the universities are 100% efficient where universities from Switzerland got the best efficiency scores. Most of the cross country are focusing on European countries and America (indicatively see Joumady and Ris 2005; St. Aubyn *et al.*, 2009; Agasisti and Perez-Esparrells, 2010). The popular non-parametric technique used in efficiency analysis is the Data Envelopment Analysis (DEA) and it occupies an important place in the comparative efficiency studies in the public sector. Particular studies include (Coelli, 1996b; Worthington, 2001; Avkiran, 2001; Abbott and Doucouliagos, 2003; Casu & Thanassoulis, 2006; Johnes, 2006; Kantabutra and Tang, 2010). Using the same technique, Worthington and Lee (2008) measure the efficiency of universities during the period 1998–2003. Johnes (1996), Athanassopoulos and Shale (1997) and Flegg *et al.* (2004) examines efficiency of universities in UK with same methodology.

DEA are said to be the most appropriate technique for public institutions like the universities given the possession of multiple inputs and outputs, Katharaki and Katharakis (2010) consistently and reliably evaluate the technical efficiency of 20 public universities in Greece using resources in two main activities; teaching and research. Their results show inefficiency in terms of human resources management, however, it shows clear opportunity to increase research activity, likewise research income. Additionally, Avkiran (2001) used DEA in analysing the relative efficiency of universities in Australia focusing on three models which are; overall performance model, performance on delivery educational service and performance on fee-paying enrolments. Efficiency difference between private and public universities in Chile is examined by Ramirez-Correa *et al.* (2012) using DEA where the outcomes reveal insignificant statistical differences between the universities. Kuah and Wong (2011) use 30 public universities in Asia and find that the universities in Asia focus more on research than teaching because the universities are found to be more efficient in research than teaching. Out of the 30 universities, only 1 university is found to be efficient both in teaching and research activities. 3 are said to be efficient in teaching only, and 11 are found to be efficient in research activities only. Nazarko and Saparauskas (2013) describe a comparative efficiency study about 19 public universities of technology and conclude that there are diversifications regarding efficiency performance in those Polish universities of technology. In the departmental units of individual universities, Aziz *et al.* (2013) use DEA to evaluate the relative efficiency of 22 academic departments of a public university in Malaysia with four different dimensional models where input-output combinations are differentially defined. They finally explain that social science base department performs efficiently better than science based.

They further expatiate those different combinations of input-output result to different efficiency levels based on sensitivity analysis. Pietrzak *et al.* (2016) empirically investigate 33 specialised social science faculties of different public universities in Poland for the academic year of 2013/2014 using DEA. They finally present 9 faculties to be full efficient with overall efficiency average index of 0.72. Basically, large literature of higher education and university efficiency is streamlined to the European, American and few Asian universities. However, in sub-Saharan Africa, only Taylor and Harris (2004) evaluate 21 South African public universities for a period of 4 years and 10 universities are found to be efficient. They additionally make a basis to the efficiency difference among the universities as a result of increase in the number of students, quality of recruited students, quality of academic staff and the level of fixed costs. Meanwhile, Abdulkareem and Oyeniran (2011) make a conceptual evaluation of university performance for sustainable development and recommend the empirical use of DEA for the universities.

METHODOLOGY AND DATA PRESENTATION

The widely known method of non-parametric technique which is largely used in efficiency studies of higher education institutions or universities, including other non-profit oriented organisations is the Data Envelopment Analysis (DEA). In this technique, specification of a priori functional form is not required and this makes the approach the most appropriate. DEA is a linear programming technique commonly used for efficiency evaluation of a set of homogenous organisations referred to as Decision Making Units (DMUs) in literature. Emerging from the production possibility frontiers which explain the estimation of greatest possible production of outputs produced at a given time, considering the inputs or resources available. Therefore, specification of inputs and outputs is a pivotal initial phase in DEA for evaluating efficiency of the institutions. The proportion of outputs to inputs is a common measure used for efficiency (Berger & Humphrey, 1997). There is no conclusive standard to guide the inputs and outputs determination and selection in the evaluation of university efficiency, however, consideration must be given to the main purpose of running a university and they are; research and teaching. This paper uses 3 inputs and 2 outputs: expenditure, student-teacher ratio, total enrolment, publications and graduates respectively as presented by Table 1. The combination of inputs and outputs in this paper reflects both research and teaching as main goals of universities: expenditure and publications reflect research; student-teacher ratio, enrolment and graduates reflect teaching.

Table 1. Input-Output variable

Inputs	Outputs
1)Expenditure EXP	1)Publications PUB
2)Student/Teacher ratio STR	2)Graduates NOG
3)Total Enrolment TNE	

Inputs

- Expenditure (EXP); total current expenditure of university each academic year
- Student: Teacher Ratio (STR); the number of students per teaching staff of university
- Total Enrolment (TNE); total number of full-time students into Degree, and post graduate programmes

Outputs

- Publications (PUB); total number of publications in journals and books each academic year
- Number of Graduates (NOG); total number of regular graduates (Degree, Masters and PhD) each academic year.

Therefore, this paper embraces the output-oriented DEA linear programming model developed by Charnes *et al.* (1978) and Anderson *et al.* (2007) adopted it in analysing the U.S universities. However, McMillan and Datta (1998) use both input-oriented and output-oriented DEA analyses and clarify that the outcomes are not sensitive to orientation. Tibenszkyne (2007) opines that the output-oriented approach is the most appropriate for higher education institutions because the axiom of cost minimisation is not recognised according to the market conditions. Therefore, this paper strictly adopts the output-oriented DEA.

$$\underset{\beta_k, \lambda}{Max} \ \beta_k$$

$$S.t \ \sum_{j=1}^{n} Y_{r,j}\lambda_j \geq \beta_k Y_{r,k}$$
$$r = 1,...,s$$

$$\sum_{j=1}^{n} X_{i,j}\lambda_j \leq X_{i,j}$$
$$i = 1,...,m$$

$$\sum_{j=1}^{n} \lambda_j = 1$$
$$\lambda \geq 0$$

The $\underset{\beta_k,\lambda}{Max} \ \beta_k$ is defined as efficiency of the universities to be maximised which is measuring the distance to efficiency frontier. $\sum_{j=1}^{n} Y_{r,j}\lambda_j \geq \beta_k Y_{r,k}$ is signifying the act of producing more output while $\sum_{j=1}^{n} X_{i,j}\lambda_j \leq X_{i,j}$ is constrain of using no more inputs. Allowing for variable return to scale by requiring that each university be compared against a full university made up of parts of one or more universities is denoted by $\sum_{j=1}^{n} X_{i,j}\lambda_j \leq X_{i,j}$ while $\sum_{j=1}^{n} \lambda_j = 1$ shows that no negative value is entertain, meaning negative values of the universities can never be used for analysis. The expression β_k is the efficiency to be maximised, and the value of $X_{i,j}$ explains the amount of the ith input going to be utilised by j^{th} university. That means 3 in this paper because we consider 3 inputs. The outputs are given by $Y_{r,j}$ for r^{th} output of the jth university. K=1…, 18 which is the universities considered to be analysed in this paper. The fundamental decision variables are λ_j which is the weight given to DMU$_j$ in its efforts to dominate DMU$_0$ or how much j^{th} university is utilised in setting a performance target for university K. Even though Nigeria has 79 public universities where 40 are federal government owned while 39 are owned by the state governments, this paper systematically samples 18 public universities which is shown in Table 2: 13 federal and 5 states owned universities, due to inability to assess data for all.

Table 2. 1st and 2nd Generation Public Universities

S/N	Institutions	Year	Ownership
1	University of Ibadan, Ibadan (UII)	1948	Federal
2	University of Nigeria, Nsukka (UNN)	1960	Federal
3	ObafemiAwolowo University, Ile-Ife (OAU)	1962	Federal
4	Ahmadu Bello University., Zaria (ABU)	1962	Federal
5	University of Lagos, Lagos (ULL)	1962	Federal
6	University of Benin, Benin City (UBB)	1970	Federal
7	Bayero University, Kano (BUK)	1975	Federal
8	University of Calabar, Calabar (UCC)	1975	Federal
9	University of Ilorin, Ilorin (UIK)	1975	Federal
10	University of Jos, Jos (UJJ)	1975	Federal
11	UsmanDanfodiyo University, Sokoto (UDU)	1975	Federal
12	University of Maiduguri, Maiduguri (UMM)	1975	Federal
13	University of Port Harcourt, Port (UPP)	1975	Federal
14	Ambrose Alli University, Ekpoma (AAU)	1980	State
15	Abia State University, Uturu (ASU)	1981	State
16	OlabisiOnabanjo University, Ago-Iwo(OOU)	1982	State
17	Ekiti State University, Ado-Ekiti (ESU)	1982	State
18	Lagos State University, Ojo Lagos (LSU)	1983	State

Table 3. Relative Technical Efficiency 2007/08-2011/12

DMU	Technical Efficiency (TE)				
	07/08	08/09	09/10	10/11	11/12
DMU_1	1.000	1.000	1.000	1.000	1.000
DMU_2	1.000	0.830	0.986	0.733	0.821
DMU_3	0.791	0.695	0.839	0.717	0.844
DMU_4	0.881	0.968	0.944	0.710	0.865
DMU_5	0.889	0.870	1.000	0.882	1.000
DMU_6	0.659	0.725	0.842	0.603	0.619
DMU_7	1.000	1.000	1.000	1.000	1.000
DMU_8	1.000	0.967	0.999	0.875	1.000
DMU_9	0.797	0.968	0.854	0.802	0.948
DMU_{10}	0.804	0.962	0.936	1.000	1.000
DMU_{11}	1.000	1.000	0.723	0.675	1.000
DMU_{12}	0.839	0.932	0.882	0.825	0.468
DMU_{13}	0.715	0.862	0.746	0.748	1.000
DMU_{14}	0.971	0.922	0.703	0.989	0.889
DMU_{15}	1.000	1.000	1.000	0.849	0.985
DMU_{16}	0.990	0.892	1.000	0.881	1.000
DMU_{17}	1.000	0.797	1.000	1.000	1.000
DMU_{18}	0.947	0.827	0.841	1.000	0.999
Mean	0.905	0.901	0.905	0.849	0.913

Hence, the paper uses only the public universities established from 1960-1970 and 1971-1983 which are respectively categorised and referred as the "First" and "Second" generation universities in Nigeria. The choice is made in order to improve the research reliability in terms of homogeneity of the selected universities because DEA assesses the relative efficiency of only homogeneous DMUs (Taylor and Harris, 2004). Therefore, data are collected from National Universities Commission (NUC) and its publications, National Bureau of Statistics (NBS) and its Annual Abstracts. Therefore, this paper usesoutput-oriented DEA to analyse the relative technical efficiency of 18 aggregate Nigerian public universities with 5combinations of inputs and outputs: 3 inputs and 2 outputs.

RESULTS AND DISCUSSION

The application of the DEA model for the 18 public universities in Nigeria from 2007/2008 to 2011/2012 academic years, the relativetechnical efficiency scores of the universities are summarised in Table 3. The relative technical efficiency estimation is done using the DEAP software (Coelli, 1996a) where the universities are randomly used and represented by DMU_1 to DMU_{18}. Out of the 18 DMUs, only 2; DMU_1 and DMU_7 are found to be fully efficient positioning at the efficiency frontier line for all whole five academic years 2007/08 to 2011/12 and serve as the benchmark for the other DMUs.

Their resources are fully used in the best possible ways toward achieving their main goals of teaching and research. However, DMU_3, DMU_4, DMU_6, DMU_9, DMU_{12} and DMU_{14} have never attained efficiency score of 1.000 in any of the 5 years under observation. The result of the efficiency index has a range of 1.000 to 0.468 for the general 5 years analysis, and has an average efficiency index of 0.734. The lowest efficiency is found at the last year of the analysis, that 2011/2012 in $DMU_{12}$and that could be attributed to the insecurity and insurgency of "Boko Haram" because the DMU is situated at the affected area and that particular time was the rising peak of the insurgency.

However, the average efficiency scores for the individual five observed years are 0.905, 0.901, 0.905, 0.849 and 0.913 respectively. Based on the results obtained, it can be concluded that the state universities are efficiently better than the federal universities because the mean performance of the state universities (0.939) outweighs that of the federal universities. Furthermore, the universities that are not efficient can improve through increasing their outputs or decreasing their inputs depending on the situation and where the DEA provides the information to the university on the exact improvements needed. For example, for DMU_{12} to be efficient in the year 2011/12 it has to improve its outputs by 213% and it has output slacks of 196.85. That also applies to other inefficient universities to improve their targets.

Conclusion

Governments are the main source of fund for public universities especially in Nigeria where there is tuition-free for all citizen students. As responsibility is increasingly accumulating to the government, so the funding of universities become scarcer couple with the increasing rate of enrolments and creation of new programmes and faculties. The need arises to checkmate the universities on how they are using their resources toward achieving their stipulated goals and objectives. In checkmating the universities, due to absence of price costs, Data Envelopment Analysis (DEA) is most popular and appropriate technique to be used, and due to it compatibility to multiple inputs and outputs. This empirical investigation of the technical efficiency uses 18 public universities in Nigeriaand determines the efficient ones serving as benchmark to the inefficient ones in order to quantify the necessary gaps to become fully efficient. However, considering limitations of this study, it has been a difficult task selecting and quantifying the appropriate inputs and outputs that control the university performance especially in developing country in Africa and Nigeria in particular. Secondly, access to data on higher education or universities in Africa and Nigeria in particular is challenging. That is the main reason this study limited the number of universities on observation to just 18 public universities.

The potential policy implications that stem from the study are basically on fund allocation to the universities and improve performance to the universities' management. Due to shortages in the governments' revenue, allocating fund to universities can be based on performance index, doing so creates multiplier effects to both the government and the universities because it create favourable competition among the universities toward being the best at a lower cost. Therefore, that hastens research output rate and competitive graduates for growth and development. Further studies should be carried on the efficiency of Nigerian universities on research aspects and teaching aspects simultaneously. Also, about an empirical study for exogenous factors that determines the efficiencies of Nigerian universities.

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