Bima Journal of Science and Technology, Vol. 5(2) Dec, 2021 ISSN: 2536-6041

# MEASURING THE RELATIVE EFFICIENCY OF THE ACADEMIC DEPARTMENTS OF GOMBE STATE UNIVERSITY USING DATA ENVELOPMENT ANALYSIS (DEA)

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## ABSTRACT

Data Envelopment Analysis (DEA) has proved to be a suitable technique for assessing efficiency of public institutions because of its unique attribute of incorporating multiple inputs and outputs. Governments at all levels are often faced with difficult challenge of determining the efficiency of the performance of Decision Making Units (DMUs) especially where profit is not a priority. The study applies BCC Output-Oriented DEA model to assess the Relative Efficiency of the Academic Departments in Gombe State University. The inputs are operating expenses, admission rate and academic staff while the outputs are number of graduates produced from each of the department. Data for 2013, 2014, 2016 and 2017 were collected from the Academic Office, Bursary Unit and Establishment Division of the university. Furthermore, multivariable correlation analysis was used to develop a relationship between input and output variables. Results obtained from the analysis indicate that nine (52.94 percent) of the DMUs are efficient while the remaining eight (47.06 percent) are inefficient. Based on that, reference sets were set for those DMUs classified as inefficient. Potential (Target) improvement for each DMU was also set as well as slack analysis. It is recommended that management should review their allocation to DMU2, DMU3, DMU4, DMU11, DMU12, DMU13, DMU14 and DMU15 with a view to improving their efficiencies.

**Keywords:** Efficiency, Inputs, Outputs, Decision Making Units, Target and Slack.

## INTRODUCTION

Data Envelopment Analysis is one of the most useful instruments available for measuring the efficiency of Decision Making Units using observable data (Delavari *et al.,* 2016; Klein, 2004; Royendegh & Erole, 2009). It is a non-parametric technique developed based on the linear programming model designed to measure the efficiency of the production units with multiple inputs and outputs such as universities, insurance organizations, hospitals and banks (Klein, 2004; Jafarnejad, 2010; Abdulkareem and Oyeniran, 2011; Wu *et al.,* 2008; Ray, 2004; Dargahi *et al.,* 2010).

In the modern knowledge-based economy, the higher education institution as the centers of the human resources development plays a significant role in the economic growth and progress of the nations (Ezati, 2012). Universities are regarded as the centers of knowledge production and transfer contributing to the economic growth of the nations. This significant contribution is commonly made possible by two major undertakings of the university that is education and research (Kao & Hung, 2008; Asadi & Aslani, 2009). Accordingly, societies tend to show a high level of sensitivity towards the performance of the universities (Jafari *et al.,* 2009).

Measuring the efficiency of the universities is not an easy undertaking for two main reasons: firstly, since the costs of the inputs and outputs are of nonprofit nature, the efficiency concept does not authentically exist in the higher education institutions. Secondly, higher education institutions tend to use several inputs to produce several outputs (Nur-Azlina *et al.,* 2013).

i. Therefore, DEA is very effective for determining the degree of efficiency and

identifying the fundamental causes of inefficiency. Accordingly, it can assist the universities in achieving their strategic objectives. Among other benefits of the DEA technique is helping the inefficient departments in regulating a strategic action plan for improvement (Tandon *et al.,* 2003). They highlighted some important reasons for measuring efficiency in education which include possibility for the system to increase its level of performance without necessarily increasing inputs very much, possibility to explore environmental factors that could directly or indirectly undermine the system's efficiency and the regular measurement of the efficiency over time helps to monitor how implemented reforms influence the technical and allocative efficiency of the system. The aim of this study was to measure the Relative Efficiency of the Academic Departments of Gombe State University using BCC – Output Oriented DEA model.

## MATERIALS AND METHODS

### Study Area

Gombe State University is located in Tudun Wada, Shamaki ward, Gombe Local Government Area, Gombe state (and a L.G.A) at $10^0$17'N and $11^0$10'E. It has an area of 52km$^2$ and an estimated population of 752,080 (National Population Commission, 2017).

### Source of Data

The data for this study was collected from the Office of the Registrar (Academic Office), Bursary unit and Establishment Division of Gombe State University.

### Decision Making Units (DMUs)

Gombe State University (GSU) is located in Gombe State Nigeria. It is a member of the Association of Commonwealth Universities (www.4icu.org Retrieved 9 March 2013). Seventeen departments were used as study DMUs because Faculties of Medicine and Pharmaceutical Sciences have no graduates at the time of the study. However, the Faculty of Education is also excluded because it depends upon other faculties as shown in table 1.

**Table 1:** Decision Making Units

| No. of DMUs | Faculties | Department (DMUs) |
|---|---|---|
| 1. | | Accounting |
| 2. | | Business Administration |
| 3. | | Economics |
| 4. | | English |
| 5. | **ARTS AND SOCIAL** | History |
| 6. | **SCIENCES** | Religious Studies |
| 7. | | Public Administration |
| 8. | | Political Science |
| 9. | | Sociology |
| 10. | | Biochemistry |
| 11. | | Biology/Botany/Biological Science |
| 12. | | Chemistry |
| 13. | | Geology |
| 14. | **SCIENCES** | Geography |
| 15. | | Microbiology |
| 16. | | Mathematics/Computer Sci./Statistics |
| 17. | | Physics |

Source: GSU Academic Office, 2019.

**Selection of Inputs and Outputs and Number of DMUs**

There is no consensus as to which variables to select in a DEA study (Jacobs *et al.,* 2006); the first and very crucial step in conducting DEA is the determination of inputs and outputs. The main important point in this process is that the input – output variables should be chosen in accordance with the type of efficiency being assessed (Sherman & Rupert, 2006). It is well known that DEA becomes sensitive to variable selection as the number of variables increases; that is, the ability to discriminate between the DMUs decreases (Smith, 1997). To preserve the discriminatory power of DEA, the number of inputs and outputs should be kept at a reasonable level (Smith, 1997).

Typically, the choice and the number of inputs and outputs, and the DMUs determine how good of a discrimination exists between efficient and inefficient units. There are two conflicting considerations when evaluating the size of the data set. One consideration is to include as many DMUs as possible because with a larger population there is a greater probability of capturing high performance units that would determine the efficient frontier and improve discriminatory power. The other conflicting consideration with a large data set is that the homogeneity of the data set may decrease. Also, the computational requirements would tend to increase with larger data sets (Golany and Roll, 2009).

There are some rules of thumb on the number of inputs and outputs to select and their relation to the number of DMUs. Boussofiane *et al.* (1991) stipulate that to get good discriminatory power out of the CCR and BCC models the lower bound on the number of DMUs should be the multiple of the number of inputs and the number of outputs. This reasoning is derived from the issue that there is flexibility in the selection of weights to assign to input and output values in determining the efficiency of each DMU. That is, in attempting to be efficient a DMU can assign all of its weight to a single input or output. The DMU that has one particular ratio of an output to an input as highest will assign all its weight to those specific inputs and outputs to appear efficient. The number of such possible inputs is the product of the number of inputs and the number of outputs. The inputs and outputs used for this study are presented in table 2.

**Table 2:** Study Input and Output Variables

| Variable | Description |
|---|---|
| **Inputs** | |
| Academic Staff (AS) | The total number of Academic Staff of each department from professors down to graduate assistants for the study period |
| Admission (A) | The total number of undergraduate students admitted for each department in 2012/2013 and 2013/2014 Academic Sessions. |
| Operating Expenses (OE) | The amount spent to pay lecturers' salaries, purchased equipment, stationery and other materials for the study period. |
| **Outputs** | |
| Degree awarded in 2016 (DA16) | The total number of graduates produced from each of the Academic Departments at the end of 2016 Academic Session. |
| Degree awarded in 2017 (DA17) | The total number of graduates produced from each of the Academic Departments at the end of 2017 Academic Session. |

**The DEA Model**

The BCC Output – Oriented (Variable Returns to Scale) model was used to compute the Relative Efficiency of the departments in Gombe State University as presented below:

$$Max\emptyset + \varepsilon\left(\sum_{i-1}^{m} S_i^- + \sum_{r-1}^{s} S_r^+\right)$$

Subject to:

$$\sum_{j-1}^{n} \lambda_j x_{ij} + S_i^- = x_{io} \qquad i = 1,.,3$$

$$\sum_{j-1}^{n} \lambda_j y_{rj} - S_r^+ = \emptyset y_{ro} \qquad r = 1,2$$

$$\sum_{j-1}^{n} \lambda_j x = 1 \qquad j = 1,2,\ldots\ldots,17 \qquad (1)$$

where;

$x_{i_j}$= amount of input i into unit j

$y_{r_j}$= amount of output r from unit j

$\lambda_j$ = variables representing the magnitude of the input and output of DMU j used in constructing an efficient comparator to $DMU_j$.

$S_i^-$ = input slacks

$S_r^+$ = output slacks

$\emptyset$ = efficiency score

$\boldsymbol{\varepsilon}$ = positive non-Archimedean infinitesimal

**Data Analysis**

The study data were analyzed using DEA Excel solver (win4deap version 2.1). The data which were collated in Excel sheet were exported into the DEA Excel solver for further analysis. The data were analyzed to determine the efficient and inefficient academic departments, set benchmark for the inefficient units and set target input-output levels for each of the DMUs. Also, descriptive statistics was used to determine the frequency of reference sets.

## RESULTS AND DISCUSSION

Table 3 shows inputs and outputs data used for each of the department. DEA Excel Solver (win4deap version 2.1) was used to run the analysis and the results are shown in Tables 3, 4, 5 6 and 7 respectively.

Table 4 above shows that nine of the sampled Academic Departments representing (52.94 per cent) are efficient because they have the efficiency score of 1. Scores are relative, not absolute – they are relative to the other units in the data set. These efficient departments are: Accounting, History, Religious Studies, Public Administration, Political Science, Sociology, Biochemistry, Mathematics/Computer Science/Statistics and Physics.

Note that the model measures 'relative' efficiency, not 'absolute' efficiency. This means that it tells us how well the departments are doing in relation to the relative efficiency score of 1.

**Table 3:** Input and Output Data

| DMUs | Department | Admission | Academic Staff | Operating Expenses (₦) | Degree Awarded (2016) | Degree Awarded (2017) |
|---|---|---|---|---|---|---|
| 1. | Accounting | 186 | 38 | 206886640.7 | 69 | 69 |
| 2. | Business Administration | 238 | 26 | 149992814.5 | 62 | 62 |
| 3. | Economics | 231 | 18 | 108615486.4 | 74 | 66 |
| 4. | English | 125 | 25 | 134476316.4 | 44 | 38 |
| 5. | History | 88 | 14 | 82754656.27 | 15 | 18 |
| 6. | Religious Studies | 284 | 42 | 227575304.7 | 140 | 98 |
| 7. | Public Administration | 175 | 16 | 124131984.4 | 70 | 97 |
| 8. | Political Science | 256 | 20 | 113787652.4 | 117 | 82 |
| 9. | Sociology | 316 | 19 | 113829652.1 | 105 | 84 |
| 10. | Biochemistry | 167 | 11 | 77582490.26 | 39 | 20 |
| 11. | Biology/Botany/ Biol. Science | 500 | 41 | 217230972.8 | 43 | 68 |
| 12. | Chemistry | 65 | 25 | 139648482.5 | 9 | 15 |
| 13. | Geology | 86 | 17 | 103443320.3 | 29 | 14 |
| 14. | Geography | 181 | 28 | 155164980.5 | 33 | 38 |
| 15. | Microbiology | 210 | 18 | 118959818.4 | 55 | 27 |
| 16. | Mathematics/Comp. Sci./Stat | 463 | 56 | 310329961 | 75 | 126 |
| 17. | Physics | 33 | 13 | 82754656.27 | 5 | 9 |

**Source**: Academic Office, Bursary and Establishment Units, 2019.

**Table 4:** Efficient Academic Departments

| DMU No. | Department | Efficiency Score |
|---|---|---|
| 1. | Accounting | 1 |
| 5. | History | 1 |
| 6. | Religious Studies | 1 |
| 7. | Public Administration | 1 |
| 8. | Political Science | 1 |
| 9. | Sociology | 1 |
| 10. | Biochemistry | 1 |
| 16. | Mathematics/Comp. Sci./Stat | 1 |
| 17. | Physics | 1 |

Table 5 shows that 8 of the Academic Departments representing (47.06 per cent) are inefficient; they are having an efficiency score of less than 1. These inefficient departments are: Business Administration, Economics, English, Biology/Botany/Biological Science, Chemistry, Geology, Geography and Microbiology. These Academic Departments are less efficient compared to the efficient departments. Thus, they are to emulate their peers (efficient departments) if they are to become efficient.

**Table 5:** Inefficient Academic Departments

| DMU No. | Department | Efficiency Score |
|---|---|---|
| 2. | Business Administration | 0.6517 |
| 3. | Economics | 0.9047 |
| 4. | English | 0.8399 |
| 11. | Biology/Botany /Biol. Science | 0.6099 |
| 12. | Chemistry | 0.5203 |
| 13. | Geology | 0.8956 |
| 14. | Geography | 0.4510 |
| 15. | Microbiology | 0.6012 |

Table 6 showed the inefficient Academic Departments and their reference sets. For example, Business Administration department should emulate the best practice from Religious Studies, Public Administration and

Political Science Departments with 0.2642, 0.5943 and 0.1415 respectively in order to become efficient. Also, Chemistry department should learn the best practices of Public Administration and Physics departments by utilizing 0.2254 and 0.7746 values respectively in order to become efficient, and so on.

Note that, the BCC output-oriented DEA model is used when a Variable Returns to Scale relationship is assumed between the input and output variables. Thus, for inefficient department to become efficient, there is possibility to maintain or decrease in inputs and increase in outputs for departments not on the efficient frontier.

**Table 6:** Inefficient Departments and Reference Sets (Benchmarks)

| DMU No. | Department | Reference Sets (Benchmark values) |
|---|---|---|
| 2 | Business Administration | 6(0.2642), 7(0.5943), 8(0.1415) |
| 3 | Economics | 7(0.2924), 8(0.1665), 9(0.3144), 10(0.2268) |
| 4 | English | 1(0.0604), 6(0.2805), 7(0.087), 17(0.5721) |
| 11 | Biology/Botany/Biological Science | 7(0.5), 16(0.5) |
| 12 | Chemistry | 7(0.2254), 17(0.7746) |
| 13 | Geology | 6(0.1134), 7(0.0396), 8(0.0848), 17(0.7622) |
| 14 | Geography | 1(0.2748), 6(0.1036), 7(0.5631), 17(0.0585) |
| 15 | Microbiology | 7(0.3815), 8(0.5508), 17(0.0677) |

**Table 7**: Improvement Table for DMU 12

| Improvement | A | AS | OE (₦) | DA16 | DA17 |
|---|---|---|---|---|---|
| Actual | 65 | 25 | 139648482.5 | 9 | 15 |
| Target | 65 | 14 | 92081106.03 | 20 | 29 |
| Slack | 0 | 11 | 47567376.47 | 11 | 14 |
| % change | 0 | 0.44 | 0.34 | 0.55 | 0.48 |

Table 7 showed the improvement for DMU12 (Chemistry Department), the number of admission made in 2012/2013 and 2013/2014 academic sessions for the chemistry department is 65 candidates and the target remained the same implies that the number of admission in that department is okay (optimum), the number of academic staff is twenty five (25) and the target is fourteen (14) academic staff meaning that there is overstaffing in the chemistry department in addition to over expenditure. On the part of output, there is underproduction, because they were able to produce only 24 graduates.

Based on the improvement Table above, the target values revealed that the chemistry department should decrease the number of staff size by 44%, operating expenses by 34% and maintaining the same number of admission to 65 candidates. On the other hand, the outputs should be increased by 55% and 48% in 2016 and 2017 respectively if they are (chemistry department) to operate efficiently. See Appendix III for improvement inputs and outputs of the inefficient departments.

## CONCLUSION

The findings of the study revealed that nine of the sampled departments representing (52.94

per cent) are efficient meaning that they are doing well in relation to the relative efficiency score of 1, whereas 8 departments representing (47.06 per cent) are inefficient; they are having an efficiency score of less than 1. The finding of the study set target input – output levels for each of the departments identified as inefficient. The study also identified areas where outputs can be possibly increased without necessarily increasing inputs.

Tandon, Lauer and Evans (2003) highlighted some important reasons for measuring efficiency in organization which include possibility of a system to increase its level of performance without necessarily increasing inputs and possibility to explore environmental factors that could directly or indirectly undermine the system's efficiency, The findings of this study justified some of these assertions and at the same time, placed emphasis on the importance and need for management of service organizations like education center to measure efficiency.

**Recommendations**

Based on the findings of the study, the following recommendations were made:

i. the managements are recommended to review the allocations of the inefficient departments with a view to improving their efficiencies.

ii. the inefficient departments are recommended to emulate best practice from their respective reference sets as shown in table 4.4.

iii. target input – output levels were set for inefficient DMUs for improved efficiency.

## REFERENCES


Abdulkareem, A.Y., Oyeniran, S. (2011). Managing the performance of Nigerian universities for sustainable development using data envelopment analysis. *International Journal of Academic Research in Business and Social Sciences.* 1(3), 1-9.

Abzari, M., BalueiJamkhaneh, H., Khazaeipul, J. and Pour-Mostafa, K. M. (2013). Performance Evaluation of the Faculties of the State Universities Using DEA and SWOT Models and Structural Equations and Presentation of Strategic Solutions for the Efficiency Enhancement. *Journal of Operations Research and its Applications*. 10(1), 19-41.

Afonso, A., Santos, M. (2005). Students and Teachers: A DEA Approach to the Relative Efficiency of Portuguese Public Universities. NEP: New Economics Papers of Education.

Afonso, A., Schuknecht, L. and Tanzi, V. (2010). Income Distribution Determinants and Public Spending Efficiency. *Journal of Economic Inequality*. Vol. 8(3), 367-389.

Agha, S. R., Kuhail, I., Abdul Nabi, N., Salem, M. and Ghanim, A. (2011). Assessment of academic departments' efficiency using data envelopment analysis. *Journal of Industrial Engineering and Management*. 4(2), 301-325.

Al-Shayea, A. S. and Battal, A. H. (2013). Evaluating the efficiency of faculties in Qassim University using data envelopment analysis. *Journal of Business Administration and Education.* 4(2), 132-138.

Asadi, A., Aslani, M. (2009). Research Efficiency Measurement of the Faculties Using DEA Model (A Case Study of Islamic Azad University, Branch of Rey). Quarterly of Educational Leadership & Management. 3(4), 55-72.

Boussofiane, A., Dyson, R.G. and Thanassoulis, E. (1991). Applied Data Envelopment Analysis. *European*

*Journal of Operational Research.* 52, 1-15.

Castano, M.C.N., Cabanda, E. (2011) Sources of efficiency and productivity growth in the Philippine state universities and colleges: a non-parametric approach. *International Business & Economics Research Journal.* 6(6): 5.

Cuenca, J.S. (2011). Efficiency of State Universities and Colleges in the Philippines: A Data Envelopment Analysis. Discussion Paper Series No. 2011 – 14.

Cunha, M., Rocha, V. (2012). On the efficiency of public higher education institutions in Portugal: an exploratory study. *FEP Working Papers*, *468*.

Dargahi, H., Masuri, N., Safdari, R., Fazayeli, S. and Yusefi, M. (2010). An Analysis of the Efficiency of the Medical Records Departments of the Tehran University of Medical University Affiliated Hospitals Using Data Envelopment Analysis (DEA). *Journal of Payavaord-e- Salamat.* 4(1&2): 9-17.

Data Envelopment Analysis (1997). A *technique for measuring the efficiency of government service delivery.* Steering Committee for the Review of Commonwealth/State Service Provision. Commonwealth of Australia.

Delavari, S., Rezaee, R. and Hatam, N. (2013). The Technical Efficiency of Departments of Shiraz Medical School in Research Arena Using Data Envelopment Analysis. *International Journal of Academic Research in Business and Social Sciences.* 3:44-52.

Delavari, S., Rezaee, R. and Hatam, N. (2016). Technical efficiency of Shiraz School of medicine in research and education domains: a data envelopment analysis. *Journal of Advances in Medical Education and Professionalism.* 4(1):13-20.

Dike, I.J. (2012). Relative Efficiency of Public Secondary Schools in Adamawa state: A data envelopment analysis perspective. *Multidisciplinary Journal of Science, Technology and Vocational Education.* 1(1), 37-50.

Ezati, M. (2012). Exploring the Factors Affecting the Educational Performance of the University's Faculties: A Qualitative Study. Quarterly of Research & Planning in the Higher Education System. No. 65, 22-45.

Golany, B. and Roll, Y. (2009). An Application Procedure for DEA. *Omega*17, 237-250.

Gombe State University. www.4icu.org Retrieved 9 March 2013.

Halkos, G., Salamouris, D. (2004). Efficiency measurement of the Greek commercial banks with the use of financial ratios: a data envelopment analysis approach. *Management Accounting Research*. 15, 201–224.

Jacobs, R., Smith, P. and Street, A. (2006). Measuring Efficiency in Health Care: Analytic Techniques and Health Policy. *Cambridge University Press*.

Jafari, A., Ehsani, M., Kheibari, M.H., Mo'emeni, M.N., (2009). Designing a Performance Evaluation System for the Physical Trainings and Sports Sciences Faculties. Sports Management. 2, 51-71.

Jafarnejad, A. (2010). Management of Modern Technology. Tehran: Tehran University. Persian.

Johnes, G. and Johnes, J. (1993). Measuring the research performance of UK economics departments: application of data envelopment analysis. *Oxford Economic Papers.* 45, 332-348.

Johnes, J. (2006). Data envelopment analysis and its application to the measurement of efficiency in higher education. *Economics of Education Review. 25*, 273-288.

Johnes, J. (2006). Measuring teaching efficiency in higher education: An application of data envelopment analysis to economics graduates from UK Universities 1993. *European Journal of Operational Research*. 174(1), 443-456.

Kao, C. and Hung, H. T. (2008). Efficiency analysis of university departments: An empirical study. *The International Journal of Management Science. 3*6, 653-664.

Kao, C., Hwang, S. (2008). O.R. Applications: Efficiency decomposition in two-stage data envelopment analysis: An application to non-life insurance companies in Taiwan, *European Journal of Operational Research.* 185, 418-429.

Klein, A. (2004). A General Model Framework for DEA. Omega, 32, pp.12-32.

Lee, B.L. (2011). Efficiency of research performance of Australian Universities: a reappraisal using a bootstrap truncated regression approach. *Economic Analysis and Policy*. 41(3): 195 – 203.

Lopes, L. and Lanzer, A. (2002). Data Envelopment Analysis – DEA and Fuzzy Sets to Assess the Performance of Academic Department: A case study at Federal University of Santa Catarina – UFSC. Pesquisa Operational. 22(2): 217-230.

Madden, G., Savage, S. and Kempkes, S. (1997). Measuring public sector efficiency: A study of the Economics Department at Australian universities. *Education Economics.* 5(2), 153-168.

Mensah, Y. M. and Shu-Hsing Li (1992). Measuring Production Efficiency in a Not-for Profit Setting: An Extension, The Accounting Review. Vol. 68(1): 66-88.

Moreno, A. and Tadepalli, R. (2002). Assessing Academic Department Efficiency a Public University. *Managerial and Decision Economics.* 23(7), 385-397.

Nazarko. J., Saparauskas. J. (2014). Application of DEA method in efficiency evaluation of public higher education institutions. *Technological and Economic Development of Economy. 20*(1), 25 – 44.

Nur-Azlina, A., Roziah-Mohd, J. and Rasidah, M. (2013). Comparative Departmental Efficiency Analysis within a University: A DEA Approach. Procedia - Social and Behavioral Sciences 90, 540 – 548.

O'Neilla, L., Raunerb, M., Heidelberger, K. and Krause, M. (2008). A cross-national comparison and taxonomy of DEA-based hospital efficiency studies. *Socioeconomic Planning Sciences.* 42, 158 – 189.

Ofe, I.I. and Chucks, M. (2014). Performance efficiency measurement in the Nigerian Public Sector: The Federal Universities Dilemma. *Mediterranean Journal of Social Sciences, Vol. 5, No. 20. MCSER Publishing, Rome-Italy. ISSN 2039-2117.*

Ray, S. C. (2004). Data envelopment analysis: theory and techniques for economics and operations research. Cambridge: Cambridge University Press.

Royendegh, B. D. and Erole, S. (2009). A DEA – ANP hybrid Algorithm Approach to Evaluate a University's Performance. *International Journal of Basic & Applied Sciences*. 9(10):115 – 29.

Sherman, H. and Rupert, T. (2006). Do bank mergers have hidden or foregone value? Realized operating synergies in one bank merger. *European Journal of Operational Research, 168*, 253-268.

Smith, P. (1997). Model misspecification in data envelopment analysis. *Annals of Operations Research, 73,* 233-252.

Somoye, R.O.C., Olayiwola, S.O., Bidmoz, B.B., Oke, D.M. and Odubunmi, A.S. (2013). Growth without development: Evidence from Public Expenditure on Health and Education in Nigeria. unilag.edu.ng/opendoc.php.

Tandon, A., Lauer, J. A. and Evans, D. B. (2003). Health System Efficiency: Concepts. In C. J. Murray, and D. B. Evans, Health Systems Performance Assessment: Debates, Methods and Empiricism (683 – 691). Geneva: World Health Organization.

Tauer, L. W., Fried, H. O. and Fry, W. E. (2007). Measuring efficiencies of academic departments within a college. Education economics, 15(4), 473-489.

Thanassoulis, E., Portela, M. and Despic, O. (2008). Data Envelopment Analysis: The mathematical programming approach to efficiency analysis. In H. Fried, K. Lovell, & Schmidt (Eds.), *Measurement of productive efficiency and productivity growth* (pp. 251 – 421). New York: Oxford University Press.

Tyagi, P., Yardav, S. P. and Singh, S. (2009). Relative performance of academic departments using DEA with sensitivity analysis. *Evaluation and Program Planning.* 32(2), 168-177.

Tzeremes, N. and Halkos, G. (2010). A DEA approach for measuring university departments' efficiency. Working paper.

Wan Husain, W.R. (2012). Comparative evaluation of public universities in Malaysia using data envelopment analysis(Unpublished doctoral dissertation). University of Warwick School of Business.

Wu, C. R., Chang, C. W. and Lin, H. L. (2008). A fuzzy ANP-based approach to evaluate medical organizational performance. *International Journal of Information and Management Sciences*. 19(1): 53-74.