THE INTERNATIONAL JOURNAL OF HUMANITIES & SOCIAL STUDIES

University of Education, Winneba Productivity and Efficiency: A Data Envelopment Analysis Exploration, Ghana

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Abstract:
This paper estimates the University of Education, Winneba productivity and efficiency using Data Envelopment Analysis (DEA). Taking full-time equivalent fulltime-students load, full-time equivalent distance-students load and full-time equivalent sandwich-students load as outputs, and the emoluments and salaries, and the book and research allowances expenditures as inputs, the results indicate that the UEW productions were technically efficient for the 2011, 2012, 2013 and 2015 academic years, whilst the 2010 and 2014 academic years were not. The results further indicate that for the 2010 academic year the input cost incurred by the UEW in producing the sandwich output could have produced 5865 sandwich students in addition and for the 2014 academic year the input cost incurred by the UEW in producing the distance output could have produced 3032 distance students more. The UEW production for academic years for 2010, 2011, 2012, 2013 exhibited constant returns to scale and that of academic years 2014 and 2015 exhibited decreasing returns to scale.

Keywords: Productivity, efficiency, data envelopment analysis, university of education, Winneba, returns to scale

1 Introduction

The University of Education, Winneba (UEW)a fully Government of Ghana (GOG) owned public HEI had been under intense pressure to provide its services as efficiently as possible, whilst undergoing huge changes in its size and structure since its inception in 1992. In an environment of expanding student numbers it is important to understand as well the cost structures that underpin provision of these outputs and the potential for UEW improved productivity and efficiency. Unfortunately there has not been any empirical study of UEW productivity and efficiency all because it is perceived as a publicly (GOG owned) HEI. As economic theory suggests, competitive pressure will affect the organisational efficiency of a firm's production processes by forcing profit-maximising firms to strive constantly to produce more efficiently. In the context of UEW the argument that such market-like mechanisms can be applied with equal force might not hold true for at least three reasons:

- The UEW is completely publicly (GOG) financed and controlled;
- And because the UEW is a non-profit entity, the 'market-driven' cost-minimisation assumption for production might not be its primary behavioural objective; and
- In the publicly (GOG) owned HEIs market in Ghana, price information of inputs and outputs are most times difficult to obtain.

To overcome this deficiency and demonstrate that the UEW productivity and efficiency measurement as a public HEI could be empirically analysed is what this paper seeks to undertake. In evaluating the UEW productivity and efficiency, its multiproduct nature as HEI is acknowledged. The paper unfolds. The next section deals with the background of UEW, followed by the data and methodology sections. The description of the variables section follows. The penultimate section presents the empirical estimates and the discussion and the last section concludes the paper.

2 Background of UEW

On 14th May, 2004 the University of Education Act, Act 672 was enacted to upgrade the status of the University College of Education of Winneba to the status of a full [public] University and to provide for related matters. The University of Education, Winneba (UEW) was established in September, 1992 as a University College under PNDC Law 322. UEW brought together seven diploma awarding college located in different towns under one umbrella institution viz the Advanced Teacher Training Colleg, the Specialist Training College, and the National Academy of Music, all at Winneba; the school of Ghana Languages, Ajumako; College of Special Education, Akwapim-Mampong; the Advanced Technical Training College, Kumasi; and the St. Andrews Agricultural Training College, Mampong-Ashanti. The UEW has a student enrolment of 51,686 as of 2015 (UEW, Basic Statistics 2015).

3. Data

A six academic year panel data (2010-2015) on UEW was obtained from the National Council for Tertiary Education (NCTE) in Accra, Ghana and the UEW 20th Congregation Basic Statistics Book (November 2015). The data from NCTE contained information on the compensation (salaries and emoluments) and book and research allowances granted to the UEW.

4. Methodology

Data Envelopment Analysis (DEA), under the assumption of a constant technology is a method for measuring efficiency of Decision Making Units (DMUs) using linear programming techniques to envelop observed input-output vectors as tightly as possible by allowing multiple inputs-outputs to be considered at the same time without any assumption on data distribution. In each case, efficiency is measured in terms of a proportional change in inputs or outputs. The model can be subdivided into input-oriented model which minimizes inputs while satisfying at least the given output levels and output-oriented model which maximizes outputs without requiring more of any of the observed input values.

DEA models can also be subdivided in term of returns to scale by adding weight constraints. Charnes, Cooper, and Rhodes (1978) originally proposed the efficiency measurement of the DMUs for constant returns to scale (CRS) where all DMUs are operating at their optimal scale. Banker, Charnes, and Cooper (1984) later on, introduced the variable returns to scale (VRS) measurement model allowing the breakdown of VRS into technical and scale efficiencies in DEA. It also makes it possible to identify the most productive scale size (MPSS) at which a DMU could operate. DEA in the present application can yield specific information about targets and benchmarks for each DMU in turn which can be used to examine savings in cost or outputs augmentations under alternative paths or priorities for efficiency and productivity gains.

By estimating efficiencies under both CRS and VRS models, it is possible to determine the scale efficiency for a DMU. The scale efficiency score for an individual DMU can be simply calculated as a ratio of its efficiency score under the CRS model to that under the VRS model. The scale efficiency of a DMU measures the extent to which a DMU can lower its cost by changing its scale size to the most productive scale size.

It is noted that the DEA estimates of efficient levels of costs or outputs are relative rather than absolute. That is to mean that each time it takes the full set of an academic year, it identifies a benchmark academic year that offers the lowest total operating cost for their mix and absolute levels of output. Those DMUs that are not on the frontier have scope for efficiency savings relative to the benchmarks. Benchmark DMUs themselves may have a scope for efficiency savings relative to some unknown absolute standards. The unknown absolute standards is a drawback of the DEA model as there are no suitable comparators for an efficient DMU mix of outputs and/or scale size. But the DEA as a non-parametric technique has the added advantage of identifying a DMU as inefficient and the benchmarks will clearly indicate why that unit is considered inefficient. UEW produce many outputs from its resources in any academic year herein refers to as a DMU in which case programming techniques have to be used to identify the piecewise linear frontier joining up all efficient DMUs. If DMUs (academic year) use m inputs to produce s outputs.

Under UEW input-oriented DEA VRS, the following linear programming is specified.

Minimize θ_k [1]

Subject to

$$y_{rk} - \sum_{j=1}^{n} \lambda_j y_{rj} \leq 0$$
$$r = 1,\ldots\ldots,s$$

$$\theta_k x_{jk} - \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0$$
$$i = 1,\ldots\ldots,m$$

$$\sum_{j=1}^{n} \lambda_j = 1, \lambda_j \geq 0, \forall j = 1,\ldots,s$$

Further UEW scale efficiency can be identified by calculating the following ratio for DMU k:

$$SCE_k = \frac{E_{k,CRS}}{E_{k,VRS}},$$
[2]

Where the numerator and denominator include efficiency, scores calculated under CRS and VRS, respectively.

The CRS efficiency score is simply calculated by deleting the constraint $\sum_{j=1}^{n} \lambda_j = 1$ from [1].

Overall UEW input-oriented efficiency of DMU k is measured by $E_k = \theta_k$

5. Descriptions of Variables

The definition of variables used in the UEW DEA efficiency analysis is presented in Table 1.

Type of variable	Variable	Description
Inputs:		
	Book research	UEW Total 2010-2015 academic years Total Book and Research Allowances in millions of Ghana Cedis
	Total cost	UEW Total 2010-2015 academic years operating cost (compensation) in millions of Ghana Cedis
Outputs:	fulltime	Full-time-equivalence Regular-Students for 2010-2015 academic years
	distance	Full-time-equivalence of students pursing distance education programmes for 2010-2015 academic years
	sandwich	Full-time-equivalence of students pursing sandwich education programmes for 2010-2015 academic years
dmu:	aca1	UEW 2010 academic year period
	aca2	UEW 2011 academic year period
	aca3	UEW 2012 academic year period
	aca4	UEW 2013 academic year period
	aca5	UEW 2014 academic year period
	aca6	UEW 2015 academic year period

Table 1: Descriptions of Variables Used in the UEW DEA Efficiency Analysis

6. Empirical Analyses and Discussion

In the empirical analysis, outputs are specified in terms of fulltime, distance and regular students which are exogenously fixed. The paper attempts to estimate the minimum cost at which UEW in any of the given dmu (academic year) could have handled the output levels that it did have. It is generally expected that UEW as a HEIs is expected to produce an output involving the provision of advice and services to business and regional development, the storage and preservation of knowledge and the provision of a source of independent comment on public issues, Verry and Layard (1975), however, there exist no published data and the paper could not consider that as an output. Table 3 presents the UEW DEA production efficiencies results file.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
			ref:	ref:	ref:	ref:	ref:	ref:	Input slack:	Input slack:	Output slack:	Output slack:	Output slack:
	Rank	theta	dmu aca1	dmu aca2	dmu aca3	dmu aca4	dmu aca5	dmu aca6	totalcost	bookresearch	fulltime	distance	sandwich
dmu: aca1	.	.	.	.	.	.	.	1	.	.	.	.	5865
dmu: aca2	1	1	.	.	0	.	.	.	.	.	0	.	.
dmu: aca3	1	1	.	0	1	.	.	.	.	.	.	.	.
dmu: aca4	4	1	.	.	.	.	.	.	7.45 e-09	.	.	.	.
dmu: aca5	5	.8552 19	.	.135 168	.	.5318 55	.	.332 977	.169 363	313596	.	3031.6 9	.
dmu: aca6	1	1	.	0	.	.	.	1	0	0	.	0	0

Table 3: Uew Dea Production Efficiencies Results File

The column 1 to the left of Table 3 identifies the dmu (academic year) being investigated. Column 2 reports the ranking of the dmu's in terms of their technical efficiency. Column 3 reports the technical efficiency computed (theta). Column 4-9 reports the various reference weights (lamdas) that are used to value the inputs. Columns 10-11 reports the input slacks, while Columns 12-14 reports the output slacks. Entries such as "." in the result file in Table 3 mean that the

value is virtually zero and less than 10 to minus 12 powers, or too small to mention. However, when sometimes analysing financial data, the distinction between zero and "." value may be required to keep the accuracy, Lee (2012). dmu's (aca2, aca3aca6) are ranked 1, DMU aca4, is ranked 4th, and dmu aca5, is ranked 5th. dmu (aca2, aca3,aca4, aca6) have technical efficiency of 1. dmu aca5 has an efficiency of .855219. dmu (aca6) is strongly efficient because it has no inputs or output slack. dmu aca5 has a technical efficiency score of 0.855219and a reduction in all inputs by 15% by UEW can be undertaken without worsening any other input and output during the 2014 academic year. Column 10 indicates that dmu aca4 has an input (totalcost) slack of 7.45e-09Ghana Cedis and dmu aca5 has an input (totalcost) slack of .169363Ghana Cedis respectively. Thus the UEW productivity of the 2013 and 2014 academic years can be improved by subtracting 7450900 and 169363 Ghana Cedis from its input (totalcost) respectively. dmu aca5 again has an input (bookresearch) slack of 313596 Ghana Cedis indicating that the UEW productivity of the 2014 academic year again could have been improved by subtracting 313596Ghana Cedis from its input (bookresearch). dmu (aca2, aca4aca6) are the referents of inefficient dmu aca5.

The sum of the referents of inefficient DMU aca5 is equal to 1 because of $\sum_{j=1}^{n} \lambda_j = 1$ in equation [1] (0.135168 + 0.531855 + 0.332977).

The results indicate that for the 2010 academic year (aca1) the input cost incurred by the UEW in producing the sandwich output could have produced 5865 sandwich students in addition andfor the 2014 academic year (aca5) the input cost incurred by the UEW in producing the distance output could have produced 3032 distance students more.

7. Conclusion

The paper had a view to exploring UEW productivity efficiency and possibilities for substitutions between inputs and outputs for six academic years and had demonstrated that it is possible to undertake such a task. The UEW productions were technically efficient for the 2011, 2012, 2013 and 2015 academic years, whilst the 2010 and 2014 academic years were not. The paper has a limitation in relation to data in that it cannot answer to the question as to what is the optimum mixof technical efficiency and technological components of the cost inputs: the total cost (compensation) and book and research allowances. Hence using the Malmquist Productivity Index (MPI) that enables the analysis of UEW productivity change by decomposing it further into its technical efficiency and technological component over the six academic years remains a high agenda for future research.

8. References

i. Banker, R. D., Charnes, A. & Cooper, W.W.(1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science* 30: 1078 -1092.
ii. Charnes, A., Cooper, W.W & Rhodes, E. 1978. Measuring the efficiency of decision-making units. *European Journal of Operational Research* 2: 429-444.
iii. Lee, C. (2012). Some Related DEA User-written Programs, San Diego Stata   Conference, July 25-26.
iv. University of Education, Winneba (2015). *20th Congregation Basic Statistics*, First Session November
v. Verry, D.W. & Layard, P.R.G. (1975). Cost functions for university teaching and research, *Economic Journal,* (85): 55-74.