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Assessing the Performance Efficiency of the Academic Departments of Tamale Polytechnic Using Data Envelopment Analysis (D.E.A.)

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Abstract: **In this age of knowledge economy, polytechnics play an important role in the development of a country. As government subsidies to polytechnics have been decreasing, more efficient use of resources becomes important for polytechnic administrators. This study applied Data Envelopment Analysis (DEA) to assess the performance efficiency of the academic departments at Tamale Polytechnic during the years 2003/2004 - 2014/2015. All the academic departments in the Polytechnic were sampled in the study. The study identifies inputs and outputs, which were used in the analyses of mainly secondary data from the Polytechnic. Findings and results from the study shows that seven out of the twelve department management units (DMUs) in the Polytechnic were being run efficiently whereas the remaining five were not being run efficiently. The efficient DMUs were using just the needed amount of inputs to produce their present levels of output. On the other hand, the inefficient DMUs were not adequately utilising their inputs in the production of their outputs. The findings offer insights on the inputs and outputs that significantly contribute to efficiencies so that inefficient departments can focus on these factors. It was recommended, among other things, that for the inefficient DMU to be efficient, management should adjust both inputs and outputs so that they will be equal at most the efficient levels.**

Keywords: **Data envelopment analysis, performance, higher learning institutions, academic, efficiency, departments.**

1. INTRODUCTION

In order to evaluate the performance of an organisation it is necessary to know its objective or justification for its existence. For many organisations, performance is *relatively* easy to measure. There is always a 'bottom line', be it the profit earned or some other summary performance measure. The organisations concerned, typically behave as if they have simple objective functions. By way of contrast, objectives in certain other types of organisation are more complex. For example, a university may seek to maximise prestige. To evaluate the performance of a university, it might make sense, therefore, to use prestige as a yardstick. But prestige is a function of other variables and in itself is not easily measured.

Using data envelopment analysis (DEA), this project work seeks to assess the performance efficiency of the academic departments of Tamale polytechnic, separating using their profitability and marketability. The technique allows one to identify those management institutions which are able to utilise their resources in a most efficient way such that the overall goals of the organisation are satisfied and total outcome maximised. If a management institution means to be effective in developing professionals who are going to be competent leaders and managers, then it would be useful to know the performance of the management institution. However, the measuring of the performance of management institutions has received very little attention compared with other industries because it is difficult to measure its output. Educational institutions play an essential role in development and it is important to find ways to measure their output.

Educational institutions support global development strategies with the necessary highly qualified manpower and research. The success of educational institutions in achieving this role necessitates for them to have a strategic plan. supported by a mechanism for monitoring, controlling and adjusting it. These institutions are comprised of academic departments (AD), therefore the success of these institutions depends on the performance of AD’s in achieving their objectives. An essential component of the mechanism is a set of performance measures that are used to assess the organisation’s performance and its ability to achieve set targets. [1][5]

Academic departments are building blocks of educational institutions. They can be thought of as a unit with multiple inputs and outputs. The process of converting these inputs to outputs is complex in nature and also the outputs are hard to measure. Therefore, measuring the performance of academic departments is a challenging problem. Performance measures must be based on a set of objectives that are linked to the mission of the department and its vision for the future. These define the customers and their requirements and the level that the organisation needs to satisfy. It stimulates internal quality improvement and external comparison. It should measure things that can be changed (things that we can influence and improve). Performance measures should be based on outputs compared to inputs. Outputs of academic departments include research; projects, graduates and inputs include faculty, resources, equipment, etc. It should also include measures for the ability of the process used for achieving the goals of the educational institutions such as the teaching process and the administration process.

Developing a set of performance measures that is strongly linked to the objectives of the organisation is essential for successful implementation of the strategic plan. It helps in monitoring strategic achievements and controlling strategic activities. There are few papers in the literature of developing performance measures for educational institutions. Some general guidelines for preparing self-assessment reports introduce an integrated framework for self-assessment at the departments of the polytechnic. The suggested five categories of performance measures include; productivity, efficiency, effectiveness, internal structure and growth and development. [6] [7]

2. METHOD

This study adopted the ex post facto and longitudinal research design. The choice was premised on the non-controllability and non-manipulability of Polytechnic input and output as well as the time frame of 2003/2004 - 2014/2015 (i.e. 12 DMUs). From a total number of 20 academic departments, 8 were identified as sample size.

The 8 academic departments used in this study are Accountancy, Agricultural Engineering, Building Technology, Secretaryship and Management, Hotel, Catering and Institutional Management, Marketing, Mechanical Engineering and Statistics. [10][11][13]

Secondary sourced data were used for the study. These were provided by the academic unit of the Polytechnic through its records, the planning unit, the public relations unit and the library of the institution. The data were considered very useful and appropriate for the study. The teaching resource was the main resource used to increase students' Knowledge. The inputs used were the number of HND students admitted in each academic year, the number of regular full-time lecturers with (P.C, M. Tech, M.Ed. MA., MBA, M.Sc., M.Phil. and PhD.) in the departments in each academic year and the number of Principal Instructors, Assistant Instructors and Instructors in each academic year. Regarding outputs, the study used diploma clas0sifications (i.e. first class, second class upper, second class lower and pass divisions were used. [8] [9] [14]

Regarding selecting the right number of inputs and outputs for a DEA application, it is recommended that the number of DMUs (n) be greater than the sum of the number of the inputs (m) plus the number of outputs (s) in order to have an adequate number of degree of freedom. There is no agreement on the number of inputs and outputs that should be used for a given number of DMUs. For instance, [2] [3] suggests that the number of the DMUs should be equal to, or greater than the product of the number of the inputs (m) and the number of outputs (s). [2], [7] recommends that the number of DMUs should be equal to, or greater than the larger of (m x s) or 3 x (m + s). Data were put in the form of tables. The mathematical programming approach was used to form the constraints and the CCR-I DEA model was then used to run for each set of data. [4]

3. RESULTS

Data Presentation and Analysis:

Results generated from the instrument are presented in the tables below.

Table 1: Input and Output data

DMUs	INPUTS			OUTPUTS	
Academic year	Enrolment	Snr. Lecturers, Lecturers &Asst. Lect.	Principal Instructor, Snr. instructor & Assist. Instructor	1st & 2nd Class upper	2nd Class Lower & pass
2003/2004	5506	15	46	425	616
2004/2005	3962	19	56	426	886

2005/2006	2400	15	56	236	618
2006/2007	2624	15	56	202	600
2007/2008	2276	37	64	253	667
2008/2009	3906	47	65	142	372
2009/2010	2198	47	57	187	568
2010/2011	5098	55	65	193	457
2011/2012	4864	44	50	273	694
2012/2013	4746	44	50	270	529
2013/2014	6008	72	66	301	599
2014/2015	6278	89	37	306	1202

Source: Author's construct, 2015

The linear programs for evaluating the 12 DMUs are given below.

Linear programs (LP) for Decision Making Unit (DMU) 1

Max=425*Y1+616*Y2;
Subject to
5506*X1+15*X2+46*X3=1;
425*Y1+616*Y2-5506*X1-15*X2-46*X3<=0;
426*Y1+886*Y2-3962*X1-19*X2-56*X3<=0;
236*Y1+618*Y2-2400*X1-15*X2-56*X3<=0;
202*Y1+600*Y2-2624*X1-15*X2-64*X3<=0;
253*Y1+667*Y2-2276*X1-37*X2-64*X3<=0;
142*Y1+372*Y2-3906*X1-47*X2-65*X3<=0;
187*Y1+568*Y2-2198*X1-47*X2-57*X3<=0;
193*Y1+457*Y2-5098*X1-55*X2-65*X3<=0;
273*Y1+694*Y2-4864*X1-44*X2-50*X3<=0;
270*Y1+529*Y2-4746*X1-44*X2-50*X3<=0;
301*Y1+599*Y2-6008*X1-72*X2-66*X3<=0;
306*Y1+1202*Y2-6278*X1-89*X2-37*X3<=0;
Y1Y2X1X2X3>=0;

Linear programs (LP) for Decision Making Unit (DMU) 2

Max=426*Y1+886*Y2;
Subject to
3962*X1+19*X2+56*X3=1;
425*Y1+616*Y2-5506*X1-15*X2-46*X3<=0;
426*Y1+886*Y2-3962*X1-19*X2-56*X3<=0;
236*Y1+618*Y2-2400*X1-15*X2-56*X3<=0;
202*Y1+600*Y2-2624*X1-15*X2-64*X3<=0;
253*Y1+667*Y2-2276*X1-37*X2-64*X3<=0;
142*Y1+372*Y2-3906*X1-47*X2-65*X3<=0;
187*Y1+568*Y2-2198*X1-47*X2-57*X3<=0;
193*Y1+457*Y2-5098*X1-55*X2-65*X3<=0;

273*Y1+694*Y2-4864*X1-44*X2-50*X3<=0;
270*Y1+529*Y2-4746*X1-44*X2-50*X3<=0;
301*Y1+599*Y2-6008*X1-72*X2-66*X3<=0;
306*Y1+1202*Y2-6278*X1-89*X2-37*X3<=0;
Y1Y2X1X2X3>=0;

Linear programs (LP) for Decision Making Unit (DMU) 3

Max=236*Y1+618*Y2;
Subject to
2400*X1+15*X2+56*X3=1;
425*Y1+616*Y2-5506*X1-15*X2-46*X3<=0;
426*Y1+886*Y2-3962*X1-19*X2-56*X3<=0;
236*Y1+618*Y2-2400*X1-15*X2-56*X3<=0;
202*Y1+600*Y2-2624*X1-15*X2-64*X3<=0;
253*Y1+667*Y2-2276*X1-37*X2-64*X3<=0;
142*Y1+372*Y2-3906*X1-47*X2-65*X3<=0;
187*Y1+568*Y2-2198*X1-47*X2-57*X3<=0;
193*Y1+457*Y2-5098*X1-55*X2-65*X3<=0;
273*Y1+694*Y2-4864*X1-44*X2-50*X3<=0;
270*Y1+529*Y2-4746*X1-44*X2-50*X3<=0;
301*Y1+599*Y2-6008*X1-72*X2-66*X3<=0;
306*Y1+1202*Y2-6278*X1-89*X2-37*X3<=0;
Y1Y2X1X2X3>=0

Linear programs (LP) for Decision Making Unit (DMU) 4

Max=202*Y1+590*Y2;
Subject to
2624*X1+15*X2+34*X3=1;
425*Y1+616*Y2-5506*X1-15*X2-46*X3<=0;
426*Y1+886*Y2-3962*X1-19*X2-56*X3<=0;
236*Y1+618*Y2-2400*X1-15*X2-56*X3<=0;
202*Y1+590*Y2-2624*X1-15*X2-34*X3<=0;
203*Y1+667*Y2-2276*X1-37*X2-64*X3<=0;
142*Y1+372*Y2-3906*X1-47*X2-65*X3<=0;
187*Y1+568*Y2-2198*X1-47*X2-57*X3<=0;
193*Y1+457*Y2-5098*X1-55*X2-65*X3<=0;
273*Y1+694*Y2-4864*X1-44*X2-50*X3<=0;
270*Y1+529*Y2-4746*X1-44*X2-50*X3<=0;
301*Y1+599*Y2-6008*X1-72*X2-66*X3<=0;
306*Y1+1202*Y2-6278*X1-89*X2-37*X3<=0;
Y1Y2X1X2X3>=0;

Linear programs (LP) for Decision Making Unit (DMU) 5

Max=203*Y1+667*Y2;

Subject to

2276*X1+37*X2+64*X3=1;

425*Y1+616*Y2-5506*X1-15*X2-46*X3<=0;

426*Y1+886*Y2-3962*X1-19*X2-56*X3<=0;

236*Y1+618*Y2-2400*X1-15*X2-56*X3<=0;

202*Y1+590*Y2-2624*X1-15*X2-34*X3<=0;

203*Y1+667*Y2-2276*X1-37*X2-64*X3<=0;

142*Y1+372*Y2-3906*X1-47*X2-65*X3<=0;

187*Y1+568*Y2-2198*X1-47*X2-57*X3<=0;

193*Y1+457*Y2-5098*X1-55*X2-65*X3<=0;

273*Y1+694*Y2-4864*X1-44*X2-50*X3<=0;

270*Y1+529*Y2-4746*X1-44*X2-50*X3<=0;

301*Y1+599*Y2-6008*X1-72*X2-66*X3<=0;

306*Y1+1202*Y2-6278*X1-89*X2-37*X3<=0;

Y1Y2X1X2X3>=0;

Linear programs (LP) for Decision Making Unit (DMU) 6

Max=142*Y1+372*Y2;

Subject to

3906*X1+47*X2+65*X3=1;

425*Y1+616*Y2-5506*X1-15*X2-46*X3<=0;

426*Y1+886*Y2-3962*X1-19*X2-56*X3<=0;

236*Y1+618*Y2-2400*X1-15*X2-56*X3<=0;

202*Y1+590*Y2-2624*X1-15*X2-34*X3<=0;

203*Y1+667*Y2-2276*X1-37*X2-64*X3<=0;

142*Y1+372*Y2-3906*X1-47*X2-65*X3<=0;

187*Y1+568*Y2-2198*X1-47*X2-42*X3<=0;

193*Y1+457*Y2-5098*X1-44*X2-57*X3<=0;

273*Y1+694*Y2-4864*X1-44*X2-50*X3<=0;

270*Y1+529*Y2-4746*X1-44*X2-50*X3<=0;

301*Y1+599*Y2-6008*X1-72*X2-66*X3<=0;

306*Y1+1202*Y2-6278*X1-89*X2-37*X3<=0;

Y1Y2X1X2X3>=0;

Linear programs (LP) for Decision Making Unit (DMU) 7

Max=187*Y1+568*Y2;

Subject to

2198*X1+47*X2+42*X3=1;

425*Y1+616*Y2-5506*X1-15*X2-46*X3<=0;

426*Y1+886*Y2-3962*X1-19*X2-56*X3<=0;

236*Y1+618*Y2-2400*X1-15*X2-56*X3<=0;
202*Y1+590*Y2-2624*X1-15*X2-34*X3<=0;
203*Y1+667*Y2-2276*X1-37*X2-64*X3<=0;
142*Y1+372*Y2-3906*X1-47*X2-65*X3<=0;
187*Y1+568*Y2-2198*X1-47*X2-42*X3<=0;
193*Y1+457*Y2-5098*X1-55*X2-65*X3<=0;
273*Y1+694*Y2-4864*X1-44*X2-50*X3<=0;
270*Y1+529*Y2-4746*X1-44*X2-50*X3<=0;
301*Y1+599*Y2-6008*X1-72*X2-66*X3<=0;
306*Y1+1202*Y2-6278*X1-89*X2-37*X3<=0;
Y1Y2X1X2X3>=0;

Linear programs (LP) for Decision Making Unit (DMU) 8

Max=193*Y1+457*Y2;
Subject to
5098*X1+44*X2+57*X3=1;
425*Y1+616*Y2-5506*X1-15*X2-46*X3<=0;
426*Y1+886*Y2-3962*X1-19*X2-56*X3<=0;
236*Y1+618*Y2-2400*X1-15*X2-56*X3<=0;
202*Y1+590*Y2-2624*X1-15*X2-34*X3<=0;
203*Y1+667*Y2-2276*X1-37*X2-64*X3<=0;
142*Y1+372*Y2-3906*X1-47*X2-65*X3<=0;
187*Y1+568*Y2-2198*X1-47*X2-42*X3<=0;
193*Y1+457*Y2-5098*X1-44*X2-57*X3<=0;
273*Y1+694*Y2-4864*X1-44*X2-50*X3<=0;
270*Y1+529*Y2-4746*X1-44*X2-50*X3<=0;
301*Y1+599*Y2-6008*X1-72*X2-66*X3<=0;
306*Y1+1202*Y2-6278*X1-89*X2-37*X3<=0;
Y1Y2X1X2X3>=0;

Linear programs (LP) for Decision Making Unit (DMU) 9

Max=273*Y1+694*Y2;
Subject to

4864*X1+44*X2+50*X3=1;
425*Y1+616*Y2-5506*X1-15*X2-46*X3<=0;
426*Y1+886*Y2-3962*X1-19*X2-56*X3<=0;
236*Y1+618*Y2-2400*X1-15*X2-56*X3<=0;
202*Y1+590*Y2-2624*X1-15*X2-34*X3<=0;
203*Y1+667*Y2-2276*X1-37*X2-64*X3<=0;
142*Y1+372*Y2-3906*X1-47*X2-65*X3<=0;
187*Y1+568*Y2-2198*X1-47*X2-42*X3<=0;

193*Y1+457*Y2-5098*X1-44*X2-57*X3<=0;
273*Y1+694*Y2-4864*X1-44*X2-50*X3<=0;
270*Y1+529*Y2-4746*X1-44*X2-50*X3<=0;
301*Y1+599*Y2-6008*X1-72*X2-66*X3<=0;
306*Y1+1202*Y2-6278*X1-89*X2-37*X3<=0;
Y1Y2X1X2X3>=0;

Linear programs (LP) for Decision Making Unit (DMU) 10

Max=270*Y1+529*Y2;
Subject to

4746*X1+44*X2+50*X3=1;
425*Y1+616*Y2-5506*X1-15*X2-46*X3<=0;
426*Y1+886*Y2-3962*X1-19*X2-56*X3<=0;
236*Y1+618*Y2-2400*X1-15*X2-56*X3<=0;
202*Y1+590*Y2-2624*X1-15*X2-34*X3<=0;
203*Y1+667*Y2-2276*X1-37*X2-64*X3<=0;
142*Y1+372*Y2-3906*X1-47*X2-65*X3<=0;
187*Y1+568*Y2-2198*X1-47*X2-42*X3<=0;
193*Y1+457*Y2-5098*X1-44*X2-57*X3<=0;
273*Y1+694*Y2-4864*X1-44*X2-50*X3<=0;
270*Y1+529*Y2-4746*X1-44*X2-50*X3<=0;
301*Y1+599*Y2-6008*X1-72*X2-66*X3<=0;
306*Y1+1202*Y2-6278*X1-89*X2-37*X3<=0;
Y1Y2X1X2X3>=0;

Linear programs (LP) for Decision Making Unit (DMU) 11
Max=301*Y1+599*Y2;
Subject to

6008*X1+72*X2+66*X3=1;
425*Y1+616*Y2-5506*X1-15*X2-46*X3<=0;
426*Y1+886*Y2-3962*X1-19*X2-56*X3<=0;
236*Y1+618*Y2-2400*X1-15*X2-56*X3<=0;
202*Y1+590*Y2-2624*X1-15*X2-34*X3<=0;
203*Y1+667*Y2-2276*X1-37*X2-64*X3<=0;
142*Y1+372*Y2-3906*X1-47*X2-65*X3<=0;
187*Y1+568*Y2-2198*X1-47*X2-42*X3<=0;
193*Y1+457*Y2-5098*X1-44*X2-57*X3<=0;
273*Y1+694*Y2-4864*X1-44*X2-50*X3<=0;
270*Y1+529*Y2-4746*X1-44*X2-50*X3<=0;
301*Y1+599*Y2-6008*X1-72*X2-66*X3<=0;
306*Y1+1202*Y2-6278*X1-89*X2-37*X3<=0;
Y1Y2X1X2X3>=0;

Linear programs (LP) for Decision Making Unit (DMU) 12

Max=306*Y1+1202*Y2;

Subject to

6278*X1+89*X2+37*X3=1;

425*Y1+616*Y2-5506*X1-15*X2-46*X3<=0;

426*Y1+886*Y2-3962*X1-19*X2-56*X3<=0;

236*Y1+618*Y2-2400*X1-15*X2-56*X3<=0;

202*Y1+590*Y2-2624*X1-15*X2-34*X3<=0;

203*Y1+667*Y2-2276*X1-37*X2-64*X3<=0;

142*Y1+372*Y2-3906*X1-47*X2-65*X3<=0;

187*Y1+568*Y2-2198*X1-47*X2-42*X3<=0;

193*Y1+457*Y2-5098*X1-44*X2-57*X3<=0;

273*Y1+694*Y2-4864*X1-44*X2-50*X3<=0;

270*Y1+529*Y2-4746*X1-44*X2-50*X3<=0;

301*Y1+599*Y2-6008*X1-72*X2-66*X3<=0;

306*Y1+1202*Y2-6278*X1-89*X2-37*X3<=0;

Y1Y2X1X2X3>=0;

Table 2: Efficiency scores of the DMUs

DMUs Academic year	**Efficiency**
2003/2004	1
2004/2005	1
2005/2006	1
2006/2007	1
2007/2008	1
2008/2009	0.3947089
2009/2010	1
2010/2011	0.4343779
2011/2012	0.6971748
2012/2013	0.6561728
2013/2014	0.5616997
2014/2015	1

Source: Author's construct, 2015

4. DISCUSSION OF FINDINGS

Key findings:

The linear programs (LPs) were formed and analysed using LINGO solver software.

From the computations above, it was realised that:

1. DMUs 1, 2, 3, 4, 5,7and 12 are overall efficient since these efficient DMUs have efficiency scores of 1 which implies that they were using the needed amount of inputs to produce their present levels of output. This means that resource allocation to DMUs in the academic departments should be based on the need of individual DMU as shown by the results of this study. This is because most DMUs were over-resourced.

2. DMUs 6, 8,9,10 and 11 are inefficient with an efficiency rating of 0.3947089, 0.4343779, 0.6971748, 0.6561728 and 0.5616997 respectively. Implying that their inputs and outputs usage was riot. Therefore, the institutional management should reduce their inputs and outputs to maintain their present level as it is also shown by the outcomes of this study.

5. CONCLUSION

This study so far reveals that the DEA techniques are useful in measuring performance efficiency of the academic departments of the Tamale Polytechnic. The findings from the research indicate that only 7out of 12 DMUs studied were performing efficiently. And these DMUs are 1, 2, 3, 4, 5,7and 12. These efficient DMUs have efficiency scores of 1 which implies that they have successfully and strategically managed and utilised all the resources available to them. No input was left idle or under utilised. Our plausible conclusion is that these DMUs should serve as benchmark for other DMUs. In addition, the instrument used, the DEA technique appears useful for decision making units or organisations particularly in Ghana. The academic departments are averagely performing well. This is as a result of the level of technical efficiency recorded by most of the DMUs evaluated. Generally, the study indicates that there was room for improvement in the academic department of the Tamale polytechnic.

REFERENCES

[1] Ahn, T., Charnes A., Cooper W. (1988). Some statistical and DEA evaluations of relative efficiencies of public and private institutions of higher learning. *Socio economics Planning Sciences,* 22(6), 259-269.

[2] Avkiran, N. (2002). *Productivity Analysis in the Service Sector*. Australia: N. K. Avkiran Publisher.

[3] Banker, R. D., Charnes, A., & Cooper, W.W. (1984). Some Models for Estimating Technical and Scale Inefficiency in Data Envelopment Analysis. *Management Science*, 30(9), 1078-1092.

[4] Charnes A., Cooper, W. Lewin A., & Seiford, L. (1994). *Data envelopment analysis: theory, methodology and application.* Boston, MA: Kluwer Academic Publishers.

[5] Charnes A., Cooper, W. W. & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operations Research*, 2:429-444.

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

[7] Ramanathan, R. (2003) An Introduction to Data Envelopment Analysis: A tool for Performance Measurement, Sage Publishing.

[8] Tamale polytechnic (2007). Second Congregation brochure. Tamale. GILLBT press

[9] Tamale polytechnic (2008). Fourth Congregation brochure. Tamale. GILLBT press

[10] Tamale polytechnic (2011). Fifth Congregation brochure. Tamale. GILLBT press

[11] Tamale polytechnic (2012). Sixth Congregation brochure. Tamale. GILLBT press

[12] Tamale polytechnic (2013). Seventh Congregation brochure. Tamale. GILLBT press

[13] Tamale polytechnic (2014). Eighth Congregation brochure. Tamale. GILLBT press

[14] Tamale polytechnic (2015). Ninth Congregation brochure. Tamale. GILLBT press