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PERFORMANCE EFFICIENCY OF CIVIL ENGINEERING PROGRAMS OF STATE UNIVERSITIES IN REGION VIII, PHILIPPINES: A DATA ENVELOPMENT ANALYSIS

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ABSTRACT

This research assessed the efficiency of seven state universities and colleges in Region VIII, Philippines offering civil engineering (CE) program using the Data Envelopment Analysis input-oriented CCR (Charnes, Cooper and Rhodes) model. The CCR model assumes a CRS (constant returns-to-scale) formulation. Slacks and performance targets were also computed using the model. Input measures considered in this study were enrolment, percentage of trained faculty, qualifications of faculty, student-faculty ratio and instructional-related expenditure per student. The output performance aspects on the other hand, were the revenue collected, number of graduates, graduation rate, and graduates' performance in the licensure examination. This study followed the stepwise approach in assessing the performance efficiency of each DMU. That is, the DEA started with one output variable and two input variables (basic models), and progressed to full-blown or integrative models with multiple input and output variables. From the DEA results, one out of the seven SUCs was found to have a high performance efficiency.

KEYWORDS: *data envelopment analysis, performance efficiency of programs, efficiency of programs, program evaluation*

INTRODUCTION

In general the concept of efficiency can be divided into two components, technical efficiency and economic efficiency (Yang, 2005) According to him, technical efficiency is the firm's ability to obtain maximal output from a given set of inputs while economic efficiency means the firm's ability to use minimal inputs to produce a given value of output. Technical efficiency considers the relationship between physical quantities of outputs while economic efficiency considers the relationship between the value of the outputs and the value of the input.

This study was conducted to assess the performance efficiency of the seven SUCs in Region VIII offering civil engineering programs as of school year 2008 - 2009. Evaluation was made This study will account the performance efficiency of four colleges of Eastern Samar State University in Borongan, Eastern Samar (ESSU-Borongan) for the periods 2005 to 2009. These are: College of Agriculture and Natural Sciences (CANS), College of Business Management and Accountancy (CBMA), College of Education (COED), and the College of Engineering and Technology (CET).

by measuring and analyzing their efficiency using the identified input and output data. The evaluation will focused on the technical efficiency of the different colleges SUCs involved by adapting a non-parametric approach popularly known as the Data Envelopment Analysis (DEA).

The website www.DEAzone explains DEA as a mathematical programming approach for considering optimum solutions relative to individual units (e.g., firms or units within) rather than assuming, as in optimized regression, that a solution applies to each decision making unit (DMU). DEA has been widely applied to problems in which answers about optimum input levels, their characteristics, and output levels were desired. There are two primary orientations of the DEA approach to assess technical efficiency: input- and output-orientation. The input based measure considers how inputs may be reduced relative to a desired output level while the. The output- based measure indicates how output could be expanded given the input levels.

In DEA, efficiency of each DMU is defined as the ratio: sum of weighted outputs/sum of weighted inputs, adjusted to be a number between 0 and 1. The less inputs consumed and the more outputs produced, the more efficient is a DMU.

The subjects of the study are the seven SUCs in Region VIII offering the civil engineering program which are the seven decision making units (DMUs). All the seven SUCs are chartered public higher educational institution established by law, administered and financially subsidized by the government and headed by a President. The management and implementation of its curricular programs are governed by the policies and standards of the Commission on Higher Education (www.ched.gov.ph).

University resources distinct for their operation such as students, teaching staff, and relevant expenditures to produce desired outcomes specifically the graduates and their performance on the licensure examination were considered as inputs and outputs respectively for each of the selected DMU.

In performing the DEA, this study applied the input-oriented CCR (Charnes, Cooper and Rhodes) model. The CCR model assumes a CRS (constant returns-to-scale) formulation. Slacks and performance targets were also computed using the model. Such a model is similar to the one used by Macatangay (2009) in determining the technical efficiency scores of the university/college libraries in Manila. Likewise, the present study considers how inputs may be reduced relative to a desired output level; that is, the less inputs consumed and with the same level of outputs, the more efficient is a DMU. Such a model is in accordance to the cost cutting measure set by the government, which is for using fewer inputs to produce the same output.

METHODOLOGY

Data on the input and output performance measures or variables were collected through documentary analysis. Collected data were summarized using descriptive statistics. Then, a screening procedure using correlation analysis was performed to identify the input and output variables to be used in the DEA. Using the identified input and output variables, the performance efficiency of each DMU was calculated as well as the slacks and performance targets for the inefficient DMUs.

Before performing DEA, the input variable qualifications of faculty, was first quantified. For educational attainment, a bachelor's degree holder earned a score of 1, a master's degree holder a score of 2, and a doctorate degree holder a score of 3. Work experience is the actual number of years the faculty has served in the college. The sum of the score for educational attainment and the work experience is the qualification value of a particular faculty. The composite score for all faculty assigned in a particular program was the one used for the DEA.

This study likewise followed stepwise approach in assessing the performance efficiency of each DMU similar to the one employed by Zheng and Stewart (2000). That is, the DEA started with one output variable and two input variables, and progressed to full-blown models with multiple input and output variables. In the first steps, these were called the basic models for assessing the efficiency where two inputs were considered to produce one or two output/s, while the full-blown model is also called integrative model where all the four selected input variables and the four output variables were used in the analysis. To identify the input and output variables that were considered in the basic models, all input and output variables were screened out

through correlation analysis to determine which of the input variables correlated well ($r \geq 0.5$) with the output variables but not with each other following the procedure used by Wooton (2003). Accordingly, bivariate correlation (Pearson r) was performed and correlation coefficients equal to or higher than 0.5 of the paired input and output variables were the ones considered in the computation of performance efficiency similar to the one employed by Zheng and Stewart (2000). Results of the DEA for the basic models were called basic performance efficiency while that for the integrative model was called the overall performance efficiency.

Results of the DEA were presented in tables and were compared to identify the DMU that has the best and the least performance. Here, if the performance efficiency index for a DMU is equal to 1, then the DMU is said to be efficient. When the performance efficiency was not equal to 1, then it suggests that the inputs and outputs levels are not good enough. Inefficient DMUs could become efficient by increasing their outputs or decreasing their inputs and that performance targets can be determined based on their relative efficiency, which could be calculated through DEA (www.DEAzone). Therefore, *slack values* and *performance targets* were also calculated by DEA and presented in tables.

The categorization used by Zheng and Stewart (2000) in analyzing the extent to which the universities they studied have excelled in the use of their resources to assess their instructional outcomes and in identifying the strategic capability of each university was also done in this study. These categories are: high, threshold, and low. A high score indicated that the efficiency on the dimension was a source of competitive advantage. Thus, a university which scored greater than 0.90 was assigned to the "high" category. If a university scored between 0.80 and 0.89 (inclusive), it was assigned to the "threshold" category. This indicated that while not a source of competitive advantage, the university was operating at an acceptable, but not competitive level of performance. If a university received a score below 0.80, it was assigned to the 'low' category. This score indicates that the university is operating at a low level of efficiency, which may or may not be purposeful.

RESULTS

Performance Measures

Table 1. Distribution of the Input Performance Measures of the State Universities in Region VIII that are Offering Civil Engineering Programs, SY 2008-2009

State Universities	Input Performance Measures (Actual Units)				
	Enrol-ment	Percentage of Trained Faculty	Qualifications of Faculty	Faculty – Student Ratio	Instructional-Related Expenditure per Student, Pesos
SUC A	326	30.0	169	1:33	6,345.50
SUC B	677	87.0	383	1:45	5,166.30
SUC C	107	20.0	61	1:21	8,404.60
SUC D	131	50.0	75	1:22	10,959.80
SUC E	79	100.0	40	1:26	7,840.70
SUC F	138	60.0	63	1:28	7,173.40
SUC G	345	62.5	157	1:43	5,841.15

Table 2. Distribution of the Output Performance Measures of the State Universities in Region VIII that are Offering Civil Engineering Programs, SY 2008-2009

State Universities	Output Performance Measures (Actual Units)			
	Revenue Collected, Pesos	Graduates	Graduation Rate, %	Graduates' Performance in Board Examination[a]
				Passing Percentage
SUC A	662,432.00	26	37	50.00
SUC B	1,518,511.00	95	71	38.94
SUC C	417,300.00	12	56	77.78
SUC D	339,866.40	17	41	36.84
SUC E	259,870.50	15	30	66.67
SUC F	289,800.00	20	72	58.33
SUC G	569,250.00	26	38	48.00

[a] *Overall rating of two examination periods in 2009 and data apply to first timers only*

Input and Output Variables for DEA Modeling

Table 3. Correlation Matrix for the Five Input Variables and Four Output Performance Variables of the Seven State Universities Offering Civil Engineering Program

Output Variables / Input Variables	Correlation Coefficients			
	Revenue Collected	**Graduates**	**Graduation Rate**	**Graduates' Performance in Board Examination**
Enrolment	0.926	0.859	-0.229	0.882
Percentage of Trained Faculty	0.262	0.507	0.764	-0.256
Qualifications of Faculty	0.779	0.784	-0.024	0.278
Faculty-Student Ratio	0.294	0.221	-0.342	0.661
Instructional-Related Expenditure per Student	0.439	0.569	0.361	-0.042

Performance Efficiency

Table 4. Performance Efficiency of the State Universities in Region 8 Offering Civil Engineering Program – Basic Models

State Universities	Performance Efficiency Index			
	Model 1	Rank	Model 2	Rank
SUC A	0.42	7	0.28	7
SUC B	0.74	3	0.50	3
SUC C	0.59	5	1.00	1
SUC D	0.68	4	0.35	5
SUC E	1.00	1	0.76	2
SUC F	0.85	2	0.48	4
SUC G	0.44	6	0.33	6

Notes:
For both models: Inputs = Enrolment, Qualification of Faculty
Model 1: Output = Graduates
Model 2: Output = Graduates' Performance in Licensure Examination

Table 5. Overall Performance Efficiency of the State Universities in Region 8 Offering Civil Engineering Program – Integrative Model

State Universities	**Overall Performance Efficiency**	
	Civil Engineering	**Qualitative Description**
SUC A	0.42	Low
SUC B	0.74	Low
SUC C	1.00	High
SUC D	0.68	Low
SUC E	1.00	High
SUC F	0.85	Threshold
SUC G	0.44	Low

Inputs = Enrolment, Qualification of Faculty
Outputs = Graduates, Graduates' Performance in Licensure Examination

Table 6. Slack Values of Input and Output Variables of the State Universities in Region VIII Offering Civil Engineering Program

State Universities	Input Variables		Output Variables	
	Enrolment	Qualifications of Faculty	Number of Graduates	Graduates' Performance in Licensure Examination
SUC A	0.00	1.65	0.00	1.13
SUC B	0.00	29.72	0.00	0.33
SUC C	0.00	0.00	0.00	0.00
SUC D	0.00	5.92	0.00	1.93
SUC E	0.00	0.00	0.00	0.00
SUC F	11.49	0.00	0.00	2.33
SUC G	15.42	0.00	0.00	0.13

Table 7. Performance Targets for the State Universities in Region VIII Offering Civil Engineering Program

State Universities	Input Variables		Output Variables	
	Enrolment	Qualifications of Faculty	Number of Graduates	Graduates' Performance in Licensure Examination[a]
SUC A	136.93	69.33	26	12.13
SUC B	500.33	253.33	95	44.33
SUC C	107.00	61.00	12	14.00
SUC D	89.53	45.33	17	7.93
SUC E	79.00	40.00	15	7.00
SUC F	105.33	53.33	20	9.33
SUC G	136.93	69.33	26	12.13

[a] *Number of passers*

DISCUSSION

There are SUCs with high percentage of trained faculty or faculty with master's degree, implying therefore a quality teaching force. There were also two SUCs that were found to have faculty-student ratio (FSR) that exceeded CHED standard of 1:40. These SUCs should strive to meet CHED standard in their resource utilization.

As to output performance measure, it was generally observed that SUCs with more enrollees have collected more revenues from their tuition fees and have turned out more graduates. Passing percentage in the licensure examinations was found variable among the seven SUCs studied and, from the results of the correlation analysis was moderately correlated with enrolment, faculty-student ratio, and qualifications of faculty.

From the results of the screening procedure (Table 3) that was conducted before the DEA, it could be implied that the most important resources in the seven SUCs under study are the human resources – students (or enrolment) and faculty (or qualifications of faculty), while the outputs of the instructional services of these SUCs are significantly seen in its graduates and their performance in licensure examination. These results corroborate study report of the Task Force on Higher Education of CHED (1995) that was assigned to develop internal and external efficiency indicators of higher education. Two of these reported indicators were enrolment (for internal efficiency) and quality that was proxied by the performance of graduates in professional board examination (for external efficiency). On the one hand, the results of the screening procedure seem to support earlier reports of Adeyemi (2010) that the relation of some teacher-related factors including teacher personal characteristics (qualification, year of experience) and students' achievement were statistically significant

and that of Hammond (2000) who found out that teacher quality characteristics such as certification status and degree in the field to be taught are positively correlated with student outcomes.

The DEA was able to map the relative performance of the seven SUCs with similar mission – that of producing civil engineers. This relative performance, or performance efficiency in the context of this study, could be interpreted as their strategic capability. In the strategic management literature, high organization performance is often posited to be the result of superior or wise use of resources. In the resource-based theory of organizations, Barney (1992) is of the view that a firm's strategic use of resources is the basis for competitive advantage and that organizations vary in their ability to effectively leverage common resources. In this study, these common resources are the input variables. Thus, borrowing the idea of Barney above, it could be said that SUC which got a performance efficiency index greater than 0.90 has utilized or allocated their available resources efficiently and effectively and so the SUC has just to sustain its superior performance; otherwise, the SUC has to look for strategic focus in utilizing its available resources to achieve improved performance efficiency.

Based on the results of the DEA (Table 5), only two SUCs were found to be at competitive advantage and have exhibited superior performance. These are SUC C and SUC E. A closer scrutiny of the resource base (Table 1 and Table 2) of SUC E would tell that enrolment to the programs were not high; in fact, it was the lowest. However, faculty assigned to the program were master's degree holder (100% trained faculty). Hence, these findings suggest that, for an SUC to perform best in offering an engineering education program, it should look into its enrolment procedure as well as the qualifications of the faculty assigned to the program.

For SUC C, the best practice was noted in enrolment of 100 which maybe just enough as well as the percentage of trained faculty which is in accord with CHED standard of 20% master's degree holder in engineering education that could be helpful in attaining the highest passing percentage of its graduates in licensure examination.

From the DEA, this study was also able to observe excess enrolment. Probably, these SUCs with excess or over enrolment have considered the revenue that could be generated from high enrolment which they can use for the operational requirements of offering the program. Assuming this is a valid reason, these SUCs have to improve their admission policy so they can recruit quality students to the program and be assured of quality graduates who would successfully pass the licensure examination. On the other hand, slacks or excesses (Table 6) were also noted in the input variable *qualifications of faculty*. Impliedly, this could mean academically qualified faculty and general quality of teaching force. The results of the study reveal excess in this input variable but shortages in the output variable *graduates' performance in licensure examination* was noted even with excess in faculty qualifications. This finding has implications on the utilization or management of resources – the academic staff. On a positive note, however, faculty with appropriate qualifications such as advanced education degrees have imparted good knowledge and skills to the students as to influence them to perform good also in the licensure examination (r=0.278, Table 3). This finds support in Koledoye (2010) who is of the view that academic qualification and knowledge of the subject matter, among others have effective impact on the teaching learning process and that teachers cannot play any role in the academic preparation of students unless properly trained. Hence, the SUCs under study should review the qualifications of their existing faculty or their faculty development program to find out if these are still attuned to the needs of the program and their clients and if these are wisely utilized.

Based on the results, this study concludes that, generally, the SUCs in Region VIII that offer the CE program have "low" performance efficiency. Only two SUCs were technically efficient characterized with less number of students admitted into the program, high percentage of trained faculty and its graduates' passing percentage in the licensure examination is at least 65%. However, these performance measures can still be improved.

Thus, in an environment of higher performance expectations and shrinking levels of financial support, efficient utilization of resources should become part of the strategic assessment of SUCs. The foregoing discussion has located probable strategies for institutional improvements for the SUCs in Region VIII that are offering civil engineering program. Since CHED's order is now focused on improving graduates' performance in licensure examination, SUCs therefore should give priority to this order. The path to excellence is often difficult to find, but real improvements in resource utilization and instructional performance may be within reach as presented in the following recommended strategies. These strategies consider human resources (faculty, instructional supervisor, and students) as well as the curriculum itself since the study believes that it is on these components or aspects of the organization that these SUCs can apply strategic management to improve instructional performance.

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