

Performance Efficiency of College of Computer Science of State Universities and Colleges in Region I: A Data Envelopment Analysis Study

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Abstract— Using the Multi-Stage Input-Oriented Constant Returns-to-Scale Data Envelopment Analysis (DEA) Model, this study determined the performance efficiency of the Colleges of Computer Science/College of Information Technology (CCS/CIT) of the State Universities and Colleges in Region I (DMMMSU, MMSU, PSU and UNP) based on their intellectual capital (Faculty and Students) and governance (Curriculum, Administration, Research, and Extension) from A.Y. 2008-2009 to A.Y. 2010-2011. Specifically, it sought answers to the following: 1) performance efficiency of the CCS/CIT as to intellectual capital and governance; 2) respondents' peer groups (model for improvement) and weights (percentage to be adapted to become fully efficient); 3) virtual inputs and outputs (potential improvements) of the respondents to be in the efficient frontier; and 4) fully efficient CCS/CIT operating with the best practices. Findings of the study showed that: 1) CCS/CIT A, CCS/CIT B and CCS/CIT D are "fully efficient" in all the performance indicators. CCS/CIT C is "fully efficient" in Faculty, Students, Curriculum, Administration and Research, but "weak efficient" in Extension; 2) "Fully efficient" CCS/CIT A, B and D have no peers and weights. CCS/CIT C needs to adapt 46% of the best practices of CCS/CIT D, being its peers and weights in Extension; 3) "Fully efficient" CCS/CIT do not have any virtual inputs and outputs. However, CCS/CIT C needs 76.92% decrease in the number of extension staff/personnel, 26.15% decrease in its number of linkages, and 168.21% in the number of clients served; and 4) All the colleges have the best practices in Faculty, Students, Curriculum, Administration and Research. CCS/CIT D has the best practices in Extension. In general, CCS/CIT D has the best practices in all the studied performance indicators.

Index Terms— Data Envelopment Analysis (DEA), Efficiency, Governance, Intellectual Capital, Peer Groups, Potential Improvement, State Universities and Colleges, Virtual Inputs, Virtual Outputs

1 INTRODUCTION

Evaluation of efficiency in education is an important task which is widely discussed by many researchers. Performance and efficiency evaluation of the set of homogenous decision making units in education (i.e. primary, secondary schools, faculty members of the same subject, universities, university departments), can significantly contribute to the improvement of educational system within the given region. Due to continuing discussion about changes in educational system especially in higher education, Jablonsky [1] highlighted that modeling in this field is of a high importance.

One of the popular tools in assessing efficiency is the Data Envelopment Analysis, popularly known as DEA. This is a method used for the measurement of efficiency in cases where multiple input and output factors are observed. DEA provides a comparative efficiency indicator of the units (institutions, organizations, industries, and other categories) being evaluated and analyzed. These units are called decision-making units (DMUs). In DEA, the relative efficiency of a DMU is the ratio of the total weighted output to the total weighted input. The efficiency score obtained is relative, not absolute. This means that the efficiency scores are derived from the given set of inputs and outputs of the identified DMUs. Thus, outliers in the data or simple manipulations of input/output may distort the shape of the best practice frontier and may alter the efficiency

scores of the DMUs. This makes it impractical to compare the results of two or more DEA studies conducted in different regions or places. [2]

One important feature of DEA is that it has the capacity to identify two or more DMUs which are deemed to be operating at best practice, referred to as "virtual best practice DMUs". That is, these DMUs achieved an efficiency score of 100%, thus, they operate along the efficient frontier. These best practice DMUs serve as benchmark for inefficient DMUs in making necessary adjustments to the latter based on the percentage or weights needed from their peers to become efficient. However, as Baldemor [3] stated in her study, in cases where all the DMUs are inefficient to some degree, it is not possible to employ test of statistical significance with DEA scores.

The basic idea of DEA is to view DMUs as productive units with multiple inputs and outputs. It assumes that all DMUs are operating in the efficient frontier and that any deviation from the frontier is due to inefficiency.

The main advantage to this method is its ability to accommodate a multiplicity of inputs and outputs. It is also useful because it takes into consideration returns to scale in calculating efficiency, allowing for the concept of increasing or decreasing efficiency based on size and output levels. A drawback of this technique is that model specification and inclusion or exclusion of variables can affect the results. [3]

Efficiency is defined as the level of performance that describes a process that uses the lowest amount of input in producing the desired amount of output. Efficiency is an important attribute because all inputs are scarce. Time, money and raw materials are limited, so it makes sense to try

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to conserve them while maintaining an acceptable level of output or a general production level. Therefore, being efficient simply means reducing the amount of wasted inputs.

Being an efficient and competent educational institution means having highly qualified pool of human resources, especially its faculty members. As the most significant resource in schools, teachers are critical in raising education standards. The quality of faculty members determines the quality of any higher education institutions. Raising teaching performance is perhaps the direction of most educational policies. Thus, the state, in coordination with the Commission on Higher Education (CHED), has set minimum standards in which the Philippine HEIs should abide with to assure Filipino students of quality higher education. Foremost to these standards is the minimum qualifications required of those who will be teaching in tertiary levels.

Another human capital which contributes to the attainment of the goals and objectives of any HEI is the students. Philippine HEIs recognize the inevitable significance of active student participations in some aspects of its organizational structure especially in the area of curriculum and other academic matters where students are the central focus. HEIs in the country consider students as active partners in the effective and full operation of the institutions. Evidence to this particular recognition of the students' significant function in the university is the giving of a position to a student representative in the Board of Regents which serves as the bridge between the students and the administrators.

Quality of management or good governance by administrators is also critical in attaining quality in higher education. Quality of management implies responsibility of all levels of management, but it must be led by the highest level of management. The systems of quality management in higher education institutions are based upon the existence of standards (models) acting like referential or a system of criteria in the case of external evaluation (quality insurance), or as a guide for the internal organization (quality management).

Srivanci [5] believed that the implementation of total quality management (TQM) in higher education involves critical issues. These include leadership, customer (students' critical issues groups) identification, cultural and organizational transformation.

Ali [6], moreover, stated that TQM is an inevitably common factor that will shape the strategies of higher educational institutions in their attempt to satisfy various stakeholders including students, parents, industry and society as a whole. It deals with issues pertaining quality in higher education and moves on to identify variables influencing quality of higher education.

The institutional performance of any educational institution in terms of effectiveness and efficiency, therefore, is greatly determined by its stakeholders, especially the quality of its human capital and the consistent delivery of good governance practices by school administrators. When the roles and functions of students, faculty members and school administrators from top level to middle level, are properly performed and executed with utmost consistency, this will directly lead to the attainment of the institution's maximum performance efficiency.

Where the world is dwelling on an economy driven by ICT, the Philippines depends largely on the global competitiveness of higher education institutions (HEIs) especially for those offering Information Technology (IT) programs for it to secure shares in the global market. And since efficiency is an indicator of competitiveness, institutional performance of Philippine IT-HEIs in terms of efficiency needs then to be assessed. Hence, this study was conceptualized.

In view of the present study, the researcher determined the performance efficiency of the College of Computer Science/College of Information Technology (CCS/CIT) of the four State Universities and Colleges in Region I – the Don Mariano Marcos Memorial State University (DMMSU) in La Union, University of Northern Philippines (UNP) in Ilocos Sur, Mariano Marcos State University (MMMSU) in Ilocos Norte, and Pangasinan State University (PSU) in Pangasinan. This study considered as its variables the respective intellectual capital (Faculty and Students) and governance (Curriculum, Administration, Research and Extension) of the four respondent colleges. These two sets of performance indicators, together with their sub-indicators, were subjected and plugged-in in the Data Envelopment Analysis (DEA) software.

Nature of DEA

Data Envelopment Analysis (DEA) is becoming an increasingly popular management tool. Developed by Charnes, Cooper and Rhodes (1978), DEA is a non-statistical and non-parametric technique used as a tool for evaluating and improving the performance of manufacturing and service operations. It estimates the maximum potential output for a given set of inputs, and has primarily been used in the estimation of efficiency. Lewis and Srinivas [7] highlight that DEA has been extensively applied in performance evaluation and benchmarking of schools, hospitals, bank branches, production plants, and others.

Trick [8] emphasizes that the purpose of *data envelopment analysis* is to compare the operating performance of a set of units. DEA compares each unit with only the "best" units. Each of the units is called a Decision Making Unit or DMU. Anderson [9] added that for a comparison to be meaningful, the DMUs being investigated should be homogeneous.

DEA relies on a productivity indicator that provides a measure of the efficiency that characterizes the operating activity of the units being compared. This measure is based on the results obtained by each unit, which is referred to as *outputs*, and on the resources utilized to achieve these results, which is generically designated as *inputs* or *production factors*. If the units are university departments, it is possible to consider as outputs the number of active teaching courses and scientific publications produced by the members of each department; the inputs may include the amount of financing received by each department, the cost of teaching, the administrative staff and the availability of offices and laboratories. [10]

A fundamental assumption behind this method is that if a given DMU, A, is capable of producing Y(A) units of output with X(A) inputs, then other DMUs should also be able to do the same if they were to operate efficiently. Similarly, if DMU B is capable of producing Y(B) units of output with X(B) units of input, then other DMUs should also be capable of the same

production schedule. DMUs A, B, and others can then be combined to form a composite DMU with composite inputs and composite outputs. Since this composite DMU does not necessarily exist, it is typically called a virtual producer. [9]

As Cooper, Seiford and Tone [11] had stated, finding the "best" virtual DMU for each real DMU is where the heart of the analysis lies. If the virtual DMU is better than the original DMU by either making more output with the same input or making the same output with less input then the original DMU is *inefficient*.

By providing the observed efficiencies of individual DMUs, DEA may help identify possible benchmarks towards which performance can be targeted. The weighted combinations of peers, and the peers themselves may provide benchmarks for relatively less efficient DMU. The actual levels of input use or output production of efficient DMU (or a combination of efficient DMUs) can serve as specific targets for less efficient organizations, while the processes of benchmark DMU can be promulgated for the information of heads of DMUs aiming to improve performance. The ability of DEA to identify possible peers or role models as well as simple efficiency scores gives it an edge over other measures such as total factor productivity indices. [12]

2 REVIEW OF LITERATURE

Seleim and Ashour [13] in their study of the human capital and organizational performance of Egyptian software companies found that the human capital indicators had a positive association on organizational performances. These indicators such as training attended and team-work practices, tended to result in superstar performers where more productivity could be translated to organizational performances. In this study, it was revealed that organizational performance in terms of export intensity in software firms is most influenced by superstar developers who have some distinct capabilities such as a high level of intelligence, creative ideas, initiation, ambition, and inimitability. They affirmed that superstar developers in software firms are able to introduce unique and smart software products and services that achieve attraction, satisfaction, and retention of customers locally and internationally. They also possess the skills, knowledge, and talent to meet the international standard for efficiency and design.

In a more or less the same context, another study of the role of human capital in the growth and development of new technology-based ventures, based on longitudinal data from 198 high-tech ventures was conducted by Shrader and Siegel [14]. Ahmad and Mushraf [15] agreed to this emphasizing in their study that there is a positive relationship between intellectual capital (consists of customer capital, human capital, structural capital, relation capital) and businesses performance (consists of innovation, rate of new product development, customer satisfaction, customer retention and operating costs).

Meanwhile, assessing the efficiency of Oklahoma Public Schools was the main objective of the study conducted by Currier. In this paper, the efficiency of the Oklahoma school districts using two different specifications is measured by the

Data Envelopment Analysis (DEA) method. To determine the possible sources of inefficiency, Currier employed a second stage Tobit regression analysis. The findings of the models are compared and both suggest that the key factors affecting efficiency measures among the Oklahoma school districts are primarily the students' characteristics and family environment. The result of her study supported the findings of past studies in Oklahoma that socioeconomic factors are the primary reasons for the variation in the efficiency of the Oklahoma school districts. [16]

Athanassopoulos and Shale [17] used DEA in their study to evaluate the efficiency of 45 "old" universities in the United Kingdom during 1992-93. Data was collected from several sources including the 1992 Research Assessment Exercise (RAE) and publications by the Universities' Statistical Record. Two general models were estimated, one seeking to estimate cost efficiency and another to estimate outcome efficiency. In their conclusions one of the key findings they point to from their study is that cost efficient universities producing high output levels do not generally equate to lower unit costs. Their other main finding is that many inefficient universities were particularly "over-resourced" in the process of producing research. From this they question whether directing resources for research based on the RAE exercise maximizes value added from additional funding.

A data envelopment analysis study of 36 Australian universities was also conducted based on 1995 data collected from Australian Department of Employment, Education, Training and Youth Affairs (DEETYA). Avkiran [18] estimated three separate performance models - 1) overall, 2) delivery of educational services, and 3) performance on fee-paying enrolments. These three models used the same two input measures which include Full Time Equivalent (FTE) academic and non-academic staff. The output measures used in each model are - Model 1 (Undergraduate enrolments, post-graduate enrolments, Research Quantum), Model 2 (Student Retention Rate, Student Progress Rate, Graduate Full-time Employment Rate) and Model 3 (Overseas Fee-paying enrolments, Non-overseas Fee-paying enrolments). Results of the analysis showed a mean efficiency score of 95.5% for the overall model, 96.7% on the delivery of services and a mean efficiency of only 63.4% in the fee-paying enrolments model. Avkiran claimed that, based on the results of the first two models, Australian universities are operating at "respectable" levels of efficiency. In the case of the third model, he concluded that the relatively low mean efficiency score is an evidence of poor capacity in attracting fee-paying students.

Martin [19], moreover, also evaluated the performance efficiency of universities in Spain and United Kingdom, respectively. His study included the 52 departments of the University of Zaragoza in Spain in the year 1999 through 4 DEA models using different combinations of inputs and outputs. The indicators included concerns both the teaching and the research

activity of the departments. Results of the models used showed that there are a majority of the departments that have been assessed efficient. Twenty-nine (29) departments are in the efficient frontier, thus, operating efficiently in the said indicators. However, there are 16 departments which did not reach the efficient frontier in all the models used. There are four departments that show scores very close to the efficiency level, to which Martin recommended that few changes is required in order to move to the efficient frontier. The departments that are farthest from the frontier, on the other hand, need to carry out fundamental reforms to become efficient.

DEA is now becoming popular in the Philippines as an effective tool in estimating efficiency. In 2009, de Guzman [20] estimated the technical efficiency of 16 selected colleges and universities in Metro Manila using academic data for the SY 2001–2005. These data were subjected to DEA. In summary, Far Eastern University (FEU) and University of Sto. Tomas (UST) obtained an overall technical efficiency score of 100% with no input/output slacks, so it continuously maintained its target during the test period. Out of the 16 schools, FEU is the most efficient when considering the number of times it was used by the other schools as a benchmark. Although on the average technical efficiency ranking, FEU tied with UST. As to scale efficiency, it had met and maintained consistently its target in all the input and output variables considered over the test period. FEU's efficiency was resulted from its increase in its educational income, especially in the school year 2002–2003. It has very minimal outflow when it comes to capital assets. However, when it comes to operating expenses, it continuously increased over the five-year period.

On average, schools posted 0.807 index score and need additional 19.3% efficiency growth to be efficient. Overall, there are top four efficient schools, with an average technical efficiency score between 99-100%, representing 25% of the sample. As a summary, the study revealed that the private higher educational institutions in Metro Manila are 81 % efficient based on an input-orientated variable returns to scale and is 19% deficit to the efficiency frontier. The new finding implies that these private higher educational institutions are relatively efficient during the test period.

Recently, [3] measured in her study the performance of the 16 different Colleges and Institutes of Don Mariano Marcos Memorial State University as to their efficiency on the following performance indicators – program requirements, instruction including faculty and students, research, and extension. The 16 DMUs were grouped into three as to their respective campuses in analyzing other performance indicators, which include budget. A multi-staged Input-oriented Constant Returns-to-Scale Model was used in the analysis of the inputs and outputs of the identified Decision Making Units. Results of the analysis showed that, as to program requirements, six or 37.5% were fully efficient while, as to instruction, 12 or 75% were found to be fully efficient in both faculty and students.

Fifteen or 93.75% and seven or 43.75% were fully efficient as to research and extension, respectively. Under others (annual budget), 66.67% or two of the three campuses were fully efficient.

Research capacities of higher education institutions increasingly receive recognition from the field of research as one important indicator in assessing the performance efficiency of the institution. A nation's overall capacity depends considerably on its research. Universities, as centers of knowledge production and generation, play a critical role in the national research. Thus, promoting research performance and striving for research excellence has become a prominent goal to be attained by universities worldwide.

One of the studies conducted in the Philippines using performance in research function was done in 2004 which measured the technical efficiency in research of State Colleges and Universities in Region XI. In this study, Cruz [21] also determined the factors of technical inefficiency for transformational leadership assessment and accountability using Tobit Analysis. He involved four regional SCUs in this study: University of Southeastern Philippines (USEP), Davao del Norte State College (DNSC), Davao Oriental State college of Sciences and Technology (DOSCST), and Southern Agri-Business and Aquatic School of Technology (SPAMAST) which were compared with "best practice" universities: University of Southern Mindanao (USM) and the Notre Dame of Marbel University (NDMU). The overall results suggest that the regional SCUs were inefficient when compared with USM in terms of technical efficiency, using value grants as output. The regional SCUs, however compared favorably with NDMU. In terms of number of publications, regional SCUs especially DOSCST and USEP fared favorably with USM and outperformed NDMU. Using Tobit Analysis, findings indicated that the age of the institution and the dummy for research allocation were determinants of technical efficiency.

The Teagle Working Group (TWC) [22] also initiated a survey establishing the connections between student learning and faculty research. The survey concluded that faculty research is critical to the enhancement of human capital. First, researchers may be better at teaching higher order skills, such as the ability to learn for oneself. Second, faculty engaging in research may be better at teaching more specialized general human capital. Third, research could make faculty better selectors of course content, and also better at conveying knowledge in its appropriate context. Specifically, they could be better at spotting and choosing to teach deeper concepts or more important topics. Finally, faculty research could provide "motivational quality" to teaching if researchers inspire or intimidate students into providing more effort. In sum, researchers could teach students not to become passive consumers of knowledge. In addition, researchers could serve as role models, because, in a way, they continue to be students themselves.

These literatures helped the author conceptualized this

study.

3 OBJECTIVES AND METHODOLOGY

3.1 Objectives of the Study

This study focused mainly on the identification and assessment of the performance efficiency of the College of Computer Science/College of Information Technology (CCS/CIT) of the four State Universities and Colleges (SUCs) in Region I, namely DMMMSU, MMSU, PSU and UNP, through their intellectual capital and governance for the last three academic years, 2008-2009 to 2010-2011, using Data Envelopment Analysis (DEA).

Specifically, this study determined the (a) performance efficiency of the CCS/CIT of the four SUCs in Region I using DEA as to intellectual capital and governance; (b) peer groups (reference or model for improvement) and weights (percentage to be adapted) of the CCS/CIT; (c) virtual inputs or virtual outputs (potential improvements) of the CCS/CIT to be in the efficient frontier; and (d) fully efficient CCS/CIT in Region I operating with the best practices, based on the findings.

3.2 Research Design

This study employed the descriptive evaluative design. It is a data-based analysis. Data were gathered from existing documents. The main objective of this study is to determine the performance efficiency of the College of Computer Science/College of Information Technology (CCS/CIT) of the four State Universities and Colleges (SUCs) in Region I using Data Envelopment Analysis in terms of the two performance indicators, namely intellectual capital and governance, for the last three academic years, 2008-2009 to 2010-2011. These two indicators are divided into areas. Each area has sub-indicators composed of input and output measures.

In this study, the method used to estimate efficiency was the non-statistical and non-parametric Data Envelopment Analysis (DEA).

3.3 Variables

The variables of this study included two performance indicators, intellectual capital and governance, of the CCS/CIT of the four SUCs in Region I to determine their performance efficiency. Intellectual capital refers to the individuals who are working within and the individuals who are related to the college by official enrolment. This is composed of faculty and students. Governance, on the other hand, speaks of curriculum administration, research, and extension.

Inputs are units of measurements. They represent the factors used to carry out the services. In this study, the performance indicators are classified into areas and sub-indicators. Each area has sub-indicators and corresponding set of inputs and outputs.

The subsequent paragraphs present the set of inputs that were analyzed under each area and sub-indicator of the intellectual capital and governance of the identified institutions:

Intellectual Capital

The inputs for faculty are: 1) number of faculty, 2) highest educational attainment (HEA), 3) number of faculty who gradu-

ated under Faculty and Staff Development Program (FSDP), 4) number of seminars and trainings attended, 5) length of service, and 6) number of faculty who took the Licensure Examination for Teachers (LET) or PBET, other Professional Board Examinations, and ICT-related examinations.

The inputs for students, on the other hand, include 1) number of students enrolled, 2) number of recognized student organizations, 3) number of athletes in sports competitions, 4) number of participants in cultural competitions, 5) number of academic and non-academic competitions attended, 6) number of campus/university level SBO officers and 7) number of non-academic scholars.

Governance

Governance performance indicator has four areas – curriculum, administration, research, and extension.

For curriculum, the following comprises input indicators: 1) number of programs offered, 2) total number of units in each program, 3) total number of hours of OJT, and 4) number of academic scholars. Inputs under administration include 1) number of administrators, 2) HEA of administrators, 3) number of administrators who graduated under FSDP, 4) number of seminars and trainings attended, 5) length of service, 6) number of years in the position, 7) number of administrators who took the LET/PBET, other Professional Board Examinations, and ICT-related Examinations, and 8) number of college-based projects, programs, or activities implemented by administrators.

Research inputs, on the other hand, are 1) number of on-going researches, 2) number of research personnel/staff, and 3) number of linkages. Extension inputs, moreover, involve 1) number of on-going extension projects, 2) number of extension staff/personnel, and 3) number of linkages.

The following are the outputs used for each indicator:

Intellectual Capital

Outputs embracing faculty are: 1) academic rank, 2) employment status, 3) number of professional organizations affiliations, 4) number of awardees, 5) performance evaluation of faculty, and 6) number of faculty who passed the identified examinations (faculty input 6).

The output indicators for students are: 1) number of graduates, 2) number of student activities, and 3) number of awardees.

Governance

Output indicators encompassing curriculum are: 1) number of accredited programs, 2) accreditation status, and 3) number of academic awardees. For administration, output indicators are: 1) HEA of administrators, 2) number of professional organizations affiliations, 3) number of awards received, and 4) performance evaluation. Outputs for research include the total numbers of 1) researches completed, 2) published researches and 3) researches presented. Figures on the 1) number of completed extension projects and 2) the total number of clients served by these projects are the output indicators in the extension.

Furthermore, point system was used for input and output indicators which are composed of sub-categories to determine

the general scores of the DMUs in these indicators, with 1 point as the lowest (see Appendix E). Mean scores of the data covering AY 2008-2009 to AY 2010-2011 were analyzed using the DEA software.

3.4 Population and Locale of the Study

The CCS/CIT of the four out of six recognized SUCs in Region I were subjected to this study. These include the CCS/CIT from DMMMSU, MMSU, PSU and UNP. Each college was considered as a single unit respondent. The results of the DEA analysis using data on intellectual capital and governance of the CCS/CIT determined their performance efficiency from AY 2008-2009 to AY 2010-2011. However, this study was not concerned of identifying the sources of inefficiencies, in cases where such conditions occur. Further, findings in the analysis also determined the fully efficient CCS/CIT of SUCs in Region I with the best practices.

To ensure ethical aspect of this study, the four colleges were represented by codes, using capital letters A to D, in Chapter 4 and 5 where the results of the analysis were discussed. This is to maintain utmost confidentiality of the identities of the four CCS/CIT or SUCs. These codes were assigned by the researcher through lottery method and were not disclosed to anyone.

3.5 Instrumentation and Data Collection

Necessary data for the study were collected from existing vital documents of the CCS/CIT of the four identified respondent SUCs in Region I. A structured instrument, which purely asks for quantitative data about the two performance indicators, was distributed to the head of the respondent college of each SUC. However, prior to the distribution of the questionnaires to the identified SUCs, an endorsement letter was secured from the Regional Office – I of the Commission on Higher Education.

Other data included in this study were gathered from existing related literature from different sources known as secondary data.

3.6 Data Analysis

This study employed the Multi-Stage Input-Oriented Constant Returns-to-Scale Model using the DEA software.

4 RESULTS AND DISCUSSION

4.1 Efficiency of CCS/CIT Along the Indicators

Table 1 presents the input and output values of the four CCS/CIT in terms of faculty indicator from which their performance efficiency scores were calculated using DEA software.

TABLE 1
EFFICIENCY SCORES OF THE CCS/CIT AS TO FACULTY

Indicators	CCS/CIT			
	A	B	C	D
Input				
1. Number of Faculty	22	12	17	38
2. Highest Educational Attainment of	67	32	42	38

Faculty					
3.	Number of Faculty who Graduated under Faculty and Staff Development Program (FSDP)	5	3	0	9
4.	Number of Seminars/Trainings Attended	51	60	49	202
5.	Length of Service of Faculty	49	27	37	60
6.	Number of Faculty who Took Professional Examinations, and IT-Related Examinations	10	8	0	13
Output					
1.	Academic Rank of Faculty	34	24	24	41
2.	Employment Status of Faculty	44	27	30	69
3.	Number of Professional Organizations Affiliations of Faculty	8	8	5	18
4.	Number of Faculty Awardees	6	12	5	4
5.	Performance Evaluation of Faculty	88	60	68	154
6.	Number of Faculty who Passed Professional Examinations, and IT-Related Examinations	8	9	0	13
Efficiency Score		1.00	1.00	1.00	1.00
		***	***	***	***
***Fully efficient		**Weak Efficient		*Inefficient	

It can be noted that 100% of the respondent colleges obtained an efficiency score equal to 1.00, described as “fully efficient”. This means that the colleges have obtained a favorable ratio between the level of input use and the obtained output values. Thus, no necessary radial movement is needed.

The figure below gives a graphical illustration of the efficiency scores of the CCS/CIT in terms of faculty. Dark blue color of the vertical bars means that the CCS/CIT are fully efficient.

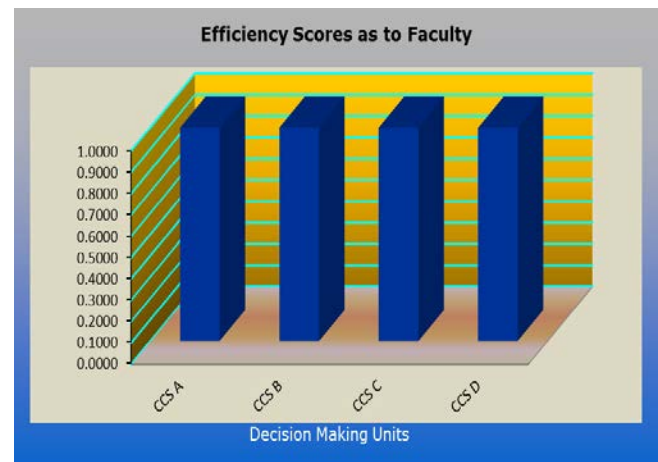


Fig. 1. Efficiency Scores Chart of the CCS/CIT along Faculty

Findings imply that the four CCS/CIT implement a standard mechanism in maintaining the quality of their faculty members.

TABLE 2
EFFICIENCY SCORES OF THE CCS/CIT AS TO STUDENTS

Indicators	CCS/CIT			
	A	B	C	D
Input				
1. Number of Students Enrolled	2651	1436	2022	4379
2. Number of Recognized Student Organizations	1	11	1	5
3. Number of Athletes in Sports Competitions	9	7	3	23
4. Number of Participants in Cultural Competitions	0	4	3	3
5. Number of Academic and Non-academic Competitions Attended	5	28	6	7
6. Number of Campus Level or University Level SBO Officers	9	4	3	4
7. Number of Non-Academic Scholars	23	29	10	52
Output				
1. Number of Graduates	883	70	792	767
2. Number of Student Activities	33	36	9	15
3. Number of Student Awardees	19	37	6	16
Efficiency Score	1.00	1.00	1.00	1.00
	***	***	***	***

***Fully efficient **Weak Efficient *Inefficient

The efficiency scores of the CCS/CIT along students indicator were identified using the input and output measures. The table also reflects the efficiency scores of the respondent colleges.

Figure 2 further illustrates the scores of the colleges in the identified indicator, which are all graphically represented by fully efficient dark blue vertical bars.

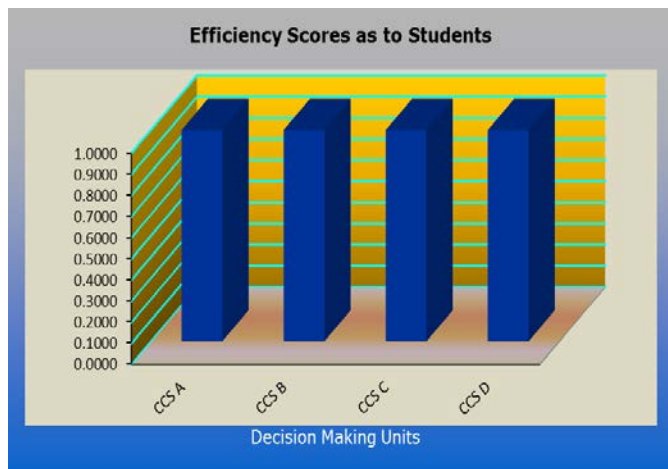


Fig. 2. Efficiency Scores Chart of the CCS/CIT along Students

Their efficiency scores of 1.00 show that the CCS/CIT are “fully efficient” in terms of students. Since they are located on the efficient frontier, there is no potential improvement required.

The results of the analysis show that the colleges recognize the inevitable significance of active student participations in some aspects of their organizational structure. The re-

spondent colleges clearly consider students as active partners in the effective and full operation of their institutions, thus, giving their respective students a favorable and strong support in matters where they are the central focus.

Consequently, their students are well engaged in different student organizations and activities. Likewise, the respondent colleges are also well represented in various academic and non-academic competitions, like athletic and cultural contests, from regional level up to higher levels of competitions. As a result of their involvement, this contributed significantly to the numerous honors and recognitions earned by the respondent colleges through the awards their students receive in the different contests. In addition, this qualified some of their students to be included in the roster of scholars.

The result also reflects the colleges’ standards for the selection, admission, and retention of their students, thus, giving a favorable ratio between enrollees and graduates.

Therefore, it can be deduced from the results that students are considered strengths of the CCS/CIT.

TABLE 3
EFFICIENCY SCORES OF THE CCS/CIT AS TO CURRICULUM

Indicators	CCS/CIT			
	A	B	C	D
Input				
1. Number of Programs Offered	3	1	3	2
2. Total Number of Units in Each Program	160	164	175	173
3. Total Number of Hours of OJT	240	162	200	240
4. Number of Academic Scholars	20	18	0	89
Output				
1. Number of Accredited Programs	1	2	1	2
2. Accreditation Status of Programs	1	2	1	2
3. Number of Academic Awardees	14	11	0	23
Efficiency Score	1.00	1.00	1.00	1.00
	***	***	***	***

***Fully efficient **Weak Efficient *Inefficient

Table 3 reveals that all the CCS/CIT are “fully efficient” in terms of curriculum, having all achieved an efficiency score of 1.00. Being fully efficient in this indicator, the respondent colleges do not need any radial movement since they are already located on the efficient frontier. This indicates that curriculum is a strength of all the colleges. Although CCS/CIT C has zero entries in the number of academic scholars and academic awardees, some aspects of its curriculum-related operations maintained an efficient production schedule. That is, the other inputs were efficiently utilized to produce outputs that are comparable with the other respondent colleges.

Figure 3 gives a clearer view of the efficiency scores of the colleges as to the indicator curriculum.

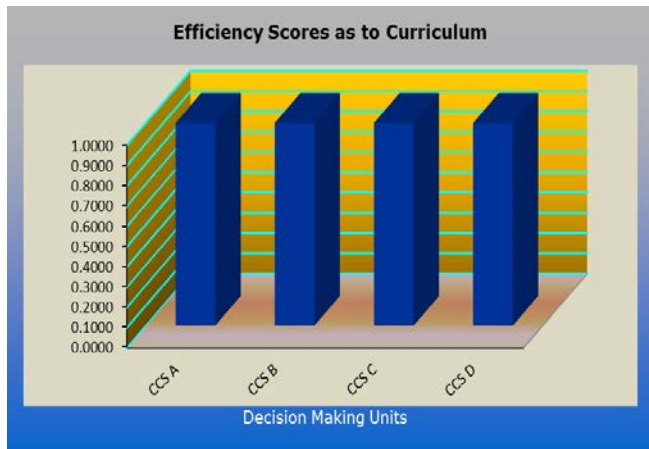


Fig. 2. Efficiency Scores Chart of the CCS/CIT along Curriculum

Although the respondent colleges have a “fully efficient” production schedule through the very favorable ratio between input and output measures as to curriculum indicator, findings imply that they should continue their current best practices in as far as curriculum matters are concerned. The colleges should continually submit their institution into any internal and external quality assurance mechanisms like accreditation by the AACCU.

TABLE 4
 EFFICIENCY SCORES OF THE CCS/CIT AS TO ADMINISTRATION

Indicators	CCS/CIT			
	A	B	C	D
Input				
1. Number of Administrators	1	1	3	3
2. Highest Educational Attainment of Administrators	5	3	10	13
3. Number of Administrators who Graduated under Faculty and Staff Development Program (FSDP)	1	0	0	2
4. Number of Seminars/Trainings Attended	23	19	35	58
5. Length of Service	5	5	8	7
6. Number of Years in the Present Position	4	1	7	8
7. Number of Administrators who Took Licensure Examination for Teachers (LET) or PBET, Other Professional Board Examinations, and ICT-Related Examinations	0	1	0	3
8. Number of college-based projects, programs, or activities implemented by Administrators	13	8	9	21
Output				
1. Academic Rank of Administrators	4	2	6	6

2. Number of Professional Organizations Affiliations	4	5	5	12
3. Number of Awards Received	4	3	1	6
4. Performance Evaluation of Administrators	4	5	12	15

Efficiency Score	1.00 ***	1.00 ***	1.00 ***	1.00 ***
***Fully efficient		**Weak Efficient	*Inefficient	

Table 4 shows that 100% of the CCS/CIT are at the “fully efficient” levels as revealed by their scores of 1.00. As a result, the colleges need not to carry out any fundamental reforms since they are already located at the efficient frontier.

The findings imply that the four colleges are governed and led by highly effective, qualified, and performing heads who achieved a desirable peer acceptance rating and had satisfied the personal and professional qualifications and competencies set by the colleges’ respective search committee. These qualifications include educational attainment, administrative experience, relevant trainings, involvement to different professional organizations, awards received, and others.

Figure 4 graphically illustrates the efficiency scores in terms of administration of the respondent colleges. The dark blue color of the vertical bars indicates that the colleges are at the efficient frontier, where their administration-related aspects are described as “fully efficient”.

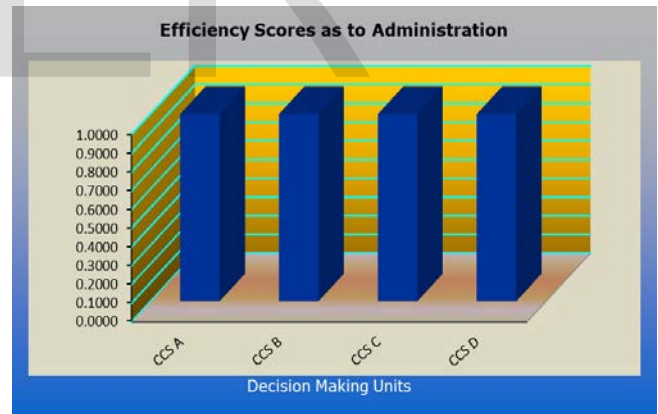


Fig. 4. Efficiency Scores Chart of the CCS/CIT along Administration

Meanwhile, research capacities of higher education institutions increasingly receive recognition as one important indicator in assessing their performance efficiency. Being a part of the four-fold functions of higher education institutions in the country, research is included as a performance indicator under governance in this study.

TABLE 5
 EFFICIENCY SCORES OF THE CCS/CIT AS TO RESEARCH

Indicators	CCS/CIT
------------	---------

	A	B	C	D
Input				
1. Number of On-going Researches	22	8	7	49
2. Number of Research Staff/Personnel	13	10	1	12
3. Number of Linkages (Local to International)	0	10	0	11
Output				
1. Number of Researches Completed	19	7	1	11
2. Number of Published Researches (Local to International)	0	0	1	12
3. Number of Researches Presented (Local to International)	0	6	0	13
Efficiency Score	1.00 ***	1.00 ***	1.00 ***	1.00 ***

***Fully efficient **Weak Efficient *Inefficient

It can be gleaned from the table that research is a strength of 100% of the respondent colleges. The colleges have obtained an efficiency score of 1.00, which indicates that their operation under research is “fully efficient”. Consequently, they do not need any radial movement or potential improvement as they are already located in the efficient frontier.

Looking at the graphical illustration of their efficiency scores in the figure 5, it can be noted that the colleges have a “fully efficient” performance in research. This is reflected in the dark blue color of the vertical bars which Data Envelopment Analysis describes as fully efficient.

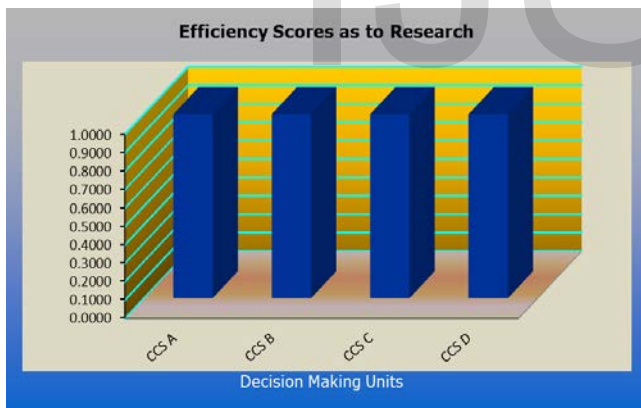


Fig. 4. Efficiency Scores Chart of the CCS/CIT along Research

Result reflects the respondent colleges’ commitment in promoting excellent research performance and striving for research excellence by providing an effective research capacity building management system. Their dedication and active involvement in research endeavors, as reflected in the number of on-going and completed researches, which were supported by the publication of their outputs in different local and international journals, and presentation to various local and international conferences, contributed significantly to the colleges’ fully efficient performances in research. The number of their respective research staff/personnel and research linkages suf-

fice the colleges’ research outputs.

TABLE 6
EFFICIENCY SCORES OF THE CCS/CIT AS TO EXTENSION

Indicators	CCS/CIT			
	A	B	C	D
Input				
1. Number of on-going Extension Projects	33	33	6	13
2. Number of Extension Staff/Personnel	7	12	2	1
3. Number of Linkages (Local to International)	0	12	5	8
Output				
1. Number of Completed Extension Projects	27	33	6	13
2. Number of Clients Served in Extension Projects	170	799	90	523
Efficiency Score	1.00 ***	1.00 ***	1.00 **	1.00 ***

***Fully efficient **Weak Efficient *Inefficient

As to extension indicator, results show that 75% of the CCS/CIT are “fully efficient” as shown in their achieved efficiency score of 1.00. These colleges, including A, B and D, are located on the efficient frontier.

On the other hand, only 1 or 25% of the respondent college is “weak efficient”. Although CCS/CIT C gained a score of 1.00, it still needs improvement to pull its location to the efficient frontier.

Figure 6 shows the graphical representation of the efficiency scores of the respondent colleges in extension.



Fig. 4. Efficiency Scores Chart of the CCS/CIT along Extension

It can be noted from the figure that only three bars were shaded with dark blue, A, B and D, which indicates full efficiency of these colleges in extension indicator. Only C has a bar shaded with cyan, which confirms its weak efficient performance.

The weak efficient performance of C may have been caused by the limited number of clients served in their extension projects in spite of having two extension staff/personnel. To become fully efficient, C must perform necessary im-

provements in its extension operations. It may consider a substantial percentage of the best practices of its peers. Further discussion on the potential improvement of C is presented in the peers and weights, and virtual input and virtual output.

4.2 Peers and Weights

One of the advantages of Data Envelopment Analysis is its capacity to provide role models (peers) for weak efficient and inefficient DMUs to become fully efficient by indicating the needed percentage of decrease or increase (weights) that these DMUs should consider from its peers to improve their efficiency. The term “peers” refers to the group of best practice organizations with which a relatively less efficient organization is compared (SCRIP/SSP, 1997).

The peers and weights of each weak efficient CCS/CIT that are necessary to bring them to the efficient frontier are shown in Table 8. The numbers in decimals and are enclosed in parentheses indicate the percentage that the weak efficient ones need to adapt from their peers.

TABLE 7
PEERS AND WEIGHTS OF THE CCS/CIT

Indicator	Peers and Weights			
	A	B	C	D
Faculty	A (1.00)	B (1.00)	C (1.00)	D (1.00)
Students	A (1.00)	B (1.00)	C (1.00)	D (1.00)
Curriculum	A (1.00)	B (1.00)	C (1.00)	D (1.00)
Administration	A (1.00)	B (1.00)	C (1.00)	D (1.00)
Research	A (1.00)	B (1.00)	C (1.00)	D (1.00)
Extension	A (1.00)	B (1.00)	D (0.46)	D (1.00)

Table 7 shows that A, B and D do not need peers as their references for improvement, since no radial movement or actions for improvement is required due to their full efficiency.

In the case of C, it is “fully efficient” in the five indicators namely faculty, students, curriculum, administration, and research indicators. Thus, it needs no reference or peers in these identified indicators. However, it is “weak efficient” in extension.

Although A and B are “fully efficient” in extension, DEA posits that D is the nearest or more similar to C in as far as extension operation is concerned. This means that C has similarities with D, than the other two fully efficient CCS/CIT, and that full efficiency in extension is more achievable for C if it makes D as its reference or model for improvement.

To become fully efficient, C needs to adapt 46% of the best practices of D in extension. There is a necessity for C to evaluate its extension program and compare it with the operations of D. It may also want to determine the factors how D was able to serve more number of clients despite its limited number of extension staff/personnel and linkages. This is further discussed in the virtual inputs/outputs of the respondent colleges under extension.

4.3 Virtual Inputs and Virtual Outputs

As discussed earlier, A, B and D are “fully efficient” as to ex-

tension indicator and that they lie along the efficient frontier. As such, these colleges no longer need target values and corresponding percentage of increase and decrease in their input and output measures. However, they should sustain their “fully efficient” performance.

CCS/CIT C, on the other hand, is the only “weak efficient” college in Extension. This means that it needs to perform necessary improvements in minimizing its input and maximizing its output to become fully efficient.

In order to become fully efficient under extension, C needs a target value of 0.46 or a decrease of 76.92% in the number of its extension staff/personnel. Originally, C has 2 extension staff/personnel. DEA result shows that C needs to reduce its staff to 0.46. In as much as decimals do not apply to people, this implies that the extension staff/personnel of C should be given other functions aside from their extension works.

Moreover, C needs to trim down its total number of extension linkages from 5 to 3.69, or equivalent to 26.15% decrease.

Despite the suggestions that C should reduce its number of staff and linkages in extension, it should target a total of 241.38 or equivalent to 168.21% increase in the number of clients served in its extension programs. From 90 clients who were served by its extension programs, C should have an additional 151.38 clients served to meet the target value for full efficiency in the extension indicator.

Although C has posted significant figures in the number of on-going and completed extension programs, these do not guarantee full efficiency for the college. This is because these numbers do not sufficiently commensurate to the number of clients served in all its extension programs, taking into considerations the number of its manpower and linkages. Despite the proposal of decreasing the number of extension staff/personnel and linkages, there is necessity for C to extend its extension programs to a wider scope of clientele to increase the number of beneficiaries.

4.4 CCS/CIT of SUCs in Region I with the Best Practices

The performance efficiency scores of the respondent colleges in the different indicators as estimated by DEA leads to the identification of CCS/CIT which are performing with the best practices. “Fully efficient” CCS/CIT which were used as references for the improvement of weak efficient ones have the best practices.

Table 8 summarizes the peers of the four respondent colleges in the different performance indicators. It also illustrates the respondent colleges with the best practices in each indicator.

TABLE 8
CCS/CIT OF SUC'S IN REGION I
WITH THE BEST PRACTICES

Indicator	Peers of CCS/CIT				CCS/CIT with the Best Practices
	A	B	C	D	
Governance					
Faculty	A	B	C	D	All
Students	A	B	C	D	All
Administration					
Curriculum	A	B	C	D	All
Administration	A	B	C	D	All
Research	A	B	C	D	All
Extension	A	B	D	D	D

Based on the table, it can be noted that there is no single CCS/CIT which is a perfect model in efficiency in the five indicators namely faculty, students, curriculum, administration, and research. The four CCS/CIT have the best practices in these indicators. This supports the findings earlier that the respondent colleges are already “fully efficient” in the identified indicators. Moreover, they do not need a peer other than their own college since their current practices as to faculty, students, curriculum, administration and research have attained full efficiency.

On the other hand, fully efficient CCS/CIT D has the best practices in extension being the only college used as model for improvement of the weak respondent CCS/CIT C.

In general, CCS/CIT D has the best practices in all the performance indicators considered in this study. It was used as reference seven times, by itself and by weak efficient CCS/CIT.

5 CONCLUSIONS

The future of every country depends largely on the quality of its higher education institutions which produce high caliber and sufficiently prepared and skilled HEIs graduates, who will soon make up its strong human capital/workforce that will toil for the betterment of its economy. Thus, constant assessment and evaluation of the performance of all HEIs is of great importance to make sure that these educational institutions are maintaining high standard operations. Hence, conducting researches such as evaluating performances of HEIs along different performance indicators is a relevant endeavor.

Where excellence places a very significant factor in global competition, especially in tertiary education, the present study might be deemed relevant in the Philippine higher education sector as it aimed at assessing the performance efficiency of the College of Computer Science/College of Information Technology of the four State Universities and Colleges in Region I based on their respective intellectual capital and governance. The comprehensive analysis of these performance indicators through the DEA will reveal the efficiency scores of these colleges hence, the identification of CCS/CIT from the SUCs in Region I with fully efficient performances.

Although they were found to be fully efficient in almost all the performance educators, the four Colleges of Computer Science/College of Information Technology (CCS/CIT) should continue implementing their current best practices in the dif-

ferent indicators in order to sustain their performance efficiency. Though they were found to be fully efficient, they should continuously integrate relevant innovations to further advance the quality and efficiency of their respective intellectual capital and governance practices. Hence, administrators and their subordinates should constantly perform evaluation of their own institution in terms of the studied indicators and other aspects of their operations, and come up with effective plans especially in investing the various aspects of human capital as it does not only direct them to attain greater performance but also it ensures them to remain competitive for their long term survival. It is recommended that their current extension programs, especially the weak efficient ones, be redesigned to accommodate greater number of clients.

Since Data Envelopment Analysis is still progressing in the region, researchers may consider in their future studies the use of Data Envelopment Analysis in evaluating the performance efficiency of other colleges, educational institutions, industries, business entities or their own organizations. As DEA does not impose a limit on the number of input and output variables to be used in calculating the desired evaluation measures, researchers may utilize additional factors, indicators, variables, and other considerations they are likely to confront. It is also recommended that the present study be replicated to verify the findings.

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