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Technical efficiency of State Universities and Colleges (SUCs) in the Philippines: A Data Envelopment Analysis (DEA) Approach

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ABSTRACT

This study utilizes data envelopment analysis (DEA) to evaluate the technical efficiency of 101 state universities and colleges (SUCs) in the Philippines. Using panel data from 2017 to 2021, it employs the output-oriented constant returns to scale (CRS) and variable returns to scale (VRS) models of DEA, considering two (2) inputs like faculty numbers and financial resources (personnel services, maintenance, and other operating expenses or MOOE, capital outlay), and measuring two (2) outputs through the total number of student enrollment and the total number of graduates. The findings reveal that out of the 101 SUCs in Region XI, only eight are deemed efficient under the output-orientated CRS model, whereas 11 are identified as efficient under the VRS model. This variance in results between the 2 DEA models employed can be attributed to their inherent methodologies: CRS tends to yield lower efficiency scores, while VRS tends to produce higher efficiency scores. The findings contribute to discussions on higher education efficiency, providing valuable insights for policymakers, administrators, and stakeholders. The study also lays the groundwork for future research on technical efficiency and productivity factors in SUCs, facilitating targeted interventions and advancements in the Philippines's higher education landscape.

Keywords: Efficiency, technical efficiency, higher education, state universities and colleges (SUCs)

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INTRODUCTION

Globally, higher education institutions (HEIs) face the challenge of thriving and adjusting to a rapidly changing environment fueled by accelerating technology. The Philippine HEIs play an essential role in the country's economy and pursuit of global competitiveness. The government has taken its role seriously in supporting the country's breakthroughs, dynamic changes in economic paradigms, and shifting societal structures. Their duties have become more significant as they assist in the advancement of economic growth (Fia et al., 2022; Mussaiyib and Pradhan, 2024), foster innovation (Mochnacs et al., 2024; Oliveira et al., 2024), and address the complex issues facing a globalized society. Recognizing the importance of cooperation and the interconnection of all people, the Philippines actively participates in the worldwide community and understands that the competitiveness of its higher education institutions is essential to its standing in international education. However, assessing from within, there is a need to look at the strengths and weaknesses of the HEIs' technical efficiency since it has far-reaching implications for the sustainability and competitiveness of public and private HEIs. For example, there are efforts to reform the subsidy system, which aims to transition from arbitrary and politically influenced allocations to a well-structured development program. This program focuses on enhancing quality, fostering innovation, and establishing effective scholarship schemes (Tan, 2011). The government recognizes the unparalleled role of the education sector, notably higher education, in the realization of its long-term goal of Ambisyon 2040, which is a "metatag, manhwa, at prenatal" (firmly grounded, comfortable, and secure) life for all Filipinos. While strides have been made in reducing poverty and boosting per capita income, the COVID-19 pandemic has posed setbacks, underscoring the fragility of these achievements. As the country navigates the initial recovery phases, the challenges have evolved, necessitating adjustments in economic and social strategies. A comprehensive economic and social transformation plan is imperative to expedite recovery, nurturing inclusive and resilient prosperity in the context of the "new normal" (NEDA, 2022).

As the regulatory body for Philippine higher education institutions, the commission on higher education (CHED) develops policies, standards, and guidelines (PSGs) governing academic programs, faculty qualifications, and resource allocation to uphold the government's agenda and promote academic excellence. The manual of regulations for private higher education (MORPHE), CMO 40 S 2008, is an example of a PSG. Its applicability to public higher education institutions is also expanded by CMO No. 30 S 2009, the applicability of the MORPHE of 2008 to state universities and colleges and local universities and colleges. SUCs are subject to this rule, which generally establishes a higher standard for higher education. The impact of CHED on SUC efficiency is especially noteworthy, considering the critical role of an effective higher education system in advancing a country. The commission's proposals impact institutional governance, faculty development, and curriculum design—all crucial components of SUC efficacy. Examining these connections contributes to a broader conversation about matching national development goals with higher education while addressing current institutional challenges. Evaluating SUC efficiency provides vital information for ongoing policy decisions and improvement in the Philippine higher education sector by showcasing how well these institutions follow CHED's mandate.

The Philippines faces several challenges, including limited financial resources, a varied geographical location, and increased student enrollment, much like other countries recovering from the COVID-19 pandemic (TUA, 2024). Another critical issue confronting the education system is the lack of resources and infrastructure in numerous rural schools. This widespread challenge significantly impacts a substantial number of schools nationwide (PIDS, 2023). Since SUCs rely on government support, examining and enhancing their performance is imperative, as these concerns directly affect their operational efficiency and productivity. The efficient distribution of inputs to produce a specific amount of output is the foundation efficiency in higher education. This encompasses combining various inputs to produce multiple outputs. Farrell (1957) pioneered the conceptualization of three efficiency types: the initial one being technical efficiency, followed by allocative efficiency, and finally, total economic efficiency. Technical efficiency specifically gauges how institutions optimally allocate physical inputs for a given output level, essentially measuring the technological efficiency of resource utilization (Ismail et al., 2014).

According to Kalirajan and Shand (1999), efficiency measurement has three advantages. First, it allows you to compare units that are similar to yours. Efficiency measurement allows for unit comparisons by determining the relative efficiency levels of homogeneous units in relation to each other. Secondly, the efficiency measurement concludes with identifying the source of efficiency differences between the units. Third, such analyses reveal some implications for increasing unit efficiency. The study can reveal the extent to which the examined units' input and output sets require improvement to enhance their efficiency. Because of the benefits of efficiency analysis, higher education institutions' efficiency is now one of the most frequently studied research topics (Acodile-Viado and Namoco, 2020; Agasisti, 2016; Agasisti and Ricca, 2016; Ampit and Tan-Cruz, 2007; Choi and Ahn, 2013; Duh et al., 2014; Kaur, 2021; Kim et al., 2022; Myeki and Temoso, 2019). Higher education efficiency research considers various types of efficiency, including cost-efficiency (Ampit & Tan-Cruz, 2007; Conchada and Zamudio, 2013; Robst, 2001), technical efficiency (Cossani et al., 2022; Kaur, 2021; Murillo, 2023; Salas-Velasco and Salas-Velasco, 2020; Villano and Tran, 2021), and allocative efficiency (Kipesha and Msigwa, 2013; Kosor, 2013). These studies highlight the effectiveness of different dimensions an units of higher education.

Evaluating technical efficiency in 101 SUCs in the Philippines employed DEA, considering both input and output variables. This method was chosen to thoroughly assess the technical efficiency of these institutions within the national higher education system. Despite resource constraints and a dynamically changing educational landscape, SUCs play a vital role in intellectual capital development andcontribute to societal and economic progress. DEA offers a tailored and robust approach, concurrently examining inputs (such as financial resources and faculty) and outputs (including student enrollment and graduation rates). Hence, the study aims to identify inefficiencies, set benchmarks, and provide insights crucial for evidence-based decision-making and policy formulation for SUCs in the Philippines.

MATERIALS AND METHODS

The research adopts a quantitative approach, utilizing DEA as the primary method for evaluating technical efficiency. This method is chosen for its ability to assess the technical efficiency of decision-making units, in this case, SUCs in the Philippines, as shown in Tables 1 to 3. The office of planning, research, and knowledge management (OPRKM) of the commission on higher education (CHED) and the Department of Budget and Management (DBM) are the two primary sources from which panel data for the study covering the years 2017–2021 were gathered. Among the significant variables included in the statistics are the number of faculty members, students, and graduates from CHED. The funding for capital expenditures, personnel services, and MOOE comes from DBM.

DEA is a commonly used technique in both the public and private sectors for evaluating performance across a set of homogeneous production units with various resources and outputs. It has a variety of applications and has been used to assess performance in a wide range of industries, such as the financial and power industries, resource allocation, police force effectiveness, and environmental efficiency. Visbal-Cadavid et al. (2017) state that DEA has also been used to assess student performance in universities, research facilities, academic programs, and elementary and secondary schools.

Numerous methodologies have been devised to gauge the effectiveness of decision-making units (DMUs), spanning various sectors such as manufacturing firms/plants, banks, hospitals, transportation systems, and educational institutions like schools and universities. Coelli (1996) introduced two efficiency metrics and outlined a procedure for their computation concerning an efficient frontier, which can be established through DEA or stochastic frontiers analysis (SFA). The principal contrast between these methodologies lies in their approach: DEA employs mathematical programming, whereas SFA relies oneconometric techniques.

Table 1. List of state universities and colleges (SUCs) in Luzon considered as decision-making units (DMUs).

Decision-Making Units (DMU)	State Universities and Colleges (SUCs) in Luzon
	National Capital Region
1	Eulogio "Amang" Rodriguez Institute of Science and Technology
2	Marikina Polytechnic College
3	Philippine Normal University
4	Philippine State College of Aeronautics
5	Polytechnic University of the Philippines
6	Rizal Technological University
7	Technological University of the Philippines
	Ilocos
8	Don Mariano Marcos Memorial State University
9	Ilocos Sur Polytechnic State College
10	Mariano Marcos State University
11	North Luzon Philippines State College
12	Pangasinan State University
13	University of Northern Philippines
	Cordillera administrative region
14	Abra State Institute of Science and Technology
15	Apayao State College
16	Benguet State University
17	Ifugao State University
18	Kalinga State University
19	Mountain Province State University
	Cagayan Valley
20	Batanes State College
21	Cagayan State University
22	Isabela State University
23	Nueva Vizcaya State University
	Quirino State University
	Central Luzon
24	Aurora State College of Technology
25	Bataan Peninsula State University
26	Bulacan Agricultural State College
27	Bulacan State University
28	Central Luzon State University
29	Don Honorio Ventura State University
30	Nueva Ecija University of Science and Technology
31	Pampanga State Agricultural University
32	Philippine Merchant Marine Academy
33	President Ramon Magsaysay State University
34	Tarlac Agricultural University
35	Tarlac State University

	Calabarzon
36	Batangas State University
37	Cavite State University
38	Laguna State Polytechnic University
39	Southern Luzon State University
40	University of Rizal System
	Mimaropa
41	Marinduque State College
42	Mindoro State University
43	Occidental Mindoro State College
44	Palawan State University
45	Romblon State University
46	Western Philippines University
	Bicol
47	Bicol State College of Applied Sciences and Technology
48	Bicol University
49	Camarines Norte State College
50	Camarines Sur Polytechnic Colleges
51	Catanduanes State University
52	Central Bicol State University of Agriculture
53	Dr. Emilio B. Espinosa, Sr. Memorial State College of Agriculture and Technology
54	Partido State University
55	Sorsogon State College

Table 2. List of state universities and colleges (SUCs) in Mindanao considered as decision-making units (DMUs).

Decision-Making Units (DMU)	State Universities and Colleges (SUCs) in Visayas
	Western Visayas
56	Aklan State University
57	Capiz State University
58	Carlos C. Hilado Memorial State College
59	Central Philippines State University
60	Guimaras State College
61	Iloilo Science and Technology University
62	Iloilo State University of Science and Technology
63	Northern Iloilo State University
64	Northern Negros State College of Science and Technology
65	University of Antique
66	West Visayas State University
	Central Visayas
67	Bohol Island State University
68	Cebu Normal University
69	Cebu Technological University
70	Siquijor State College
	Eastern Visayas
71	Eastern Samar State University
72	Eastern Visayas State University
73	Leyte Normal University
74	Northwest Samar State University
75	Palompon Polytechnic State University
76	Samar State University
77	Southern Leyte State University
78	University of Eastern Philippines
79	Visayas State University

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Table 3. List of state universities and colleges (SUCs) in Mindanao considered as decision-making units (DMUs).

Decision-Making Units (DMU)	State Universities And Colleges (SUCs) in Visayas
	Zamboanga Peninsula
80	Jose Rizal Memorial State University
81	Western Mindanao State University
82	Zamboanga City State Polytechnic College
83	Zamboanga State College of Marine Sciences and Technology
	Northen Mindanao
84	Bukidnon State University
85	Camiguin Polytechnic State College
86	Central Mindanao University
87	Northwestern Mindanao State College of Science and Technology
88	University of Science and Technology of Southern Philippines-Cagayan de Oro Campus
	Davao Region
89	Compostela Valley State College
90	Davao Del Norte State College
91	Davao Oriental State University
92	Southern Philippines Agri-Business and Marine and Aquatic School of Technology
93	University of Southeastern Philippines
	Main soccsksargen
94	Cotabato Foundation College of Science and Technology
95	Sultan Kudarat State University
96	University of Southern Mindanao
	Caraga
97	Agusan del Sur State College of Agriculture and Technology
98	Caraga State University
99	Surigao State College of Technology
	Bangsamoro Autonomous Region in Muslim Mindanao (BARMM)
100	Cotabato State University
101	Mindanao State University

Cuenca's (2011) paper cites prior research (Flegg et al., 2003; Kempkes and Pohl, 2010; Talluri, 2000) that DEA is useful for assessing DMUs with various inputs and outputs, such as institutions and colleges. DEA is a linear programming technique that evaluates the relative efficiency or inefficiency of a homogenous collection of DMUs by creating a non-parametric envelopment frontier using the input and output data currently available. Next, the efficiency of the DMUs is computed in relation to this boundary. Based on the existing studies (Flegg et al., 2003; Talluri, 2000), the efficiency score of DMUs with multiple input and output factors is defined as:

$$Efficiency = \frac{weighted\ sum\ of\ outputs}{weighted\ sum\ of\ inputs}$$

A typical DEA model can be described using either an input-oriented or an output-oriented approach. Regardless of the orientation used, the efficiency measurements for DMUs assume CRS. Conversely, these measurements can vary based on the orientation chosen within the VRS framework. Nevertheless, the set of DMUs identified as inefficient under the VRS framework remains consistent regardless of the orientation selected (Thanassoulis et al., 2011).

The study specifically employs output-oriented CRS and VRS models. The main points for assessing efficiency are the DMUs, representing the various SUCs in the Philippines. The study emphasizes how important it is to carry out a comprehensive data collection procedure that covers essential inputs, such as faculty members and financial resources, in addition to outputs, such as graduation rates and overall student enrollment. The study evaluates the technical efficiency of 101 SUCs in the Philippines between 2017 and 2021 using two distinct models: the output-oriented CRS and VRS. The CRS model suggests that in order to maximize output while maintaining constant input levels, growing production size enhances output while preserving resource utilization efficiency. Conversely, the VRS model considers input level changes and acknowledges that production volume changes may impact resource usage efficiency. This approach allows for a more sophisticated assessment of efficiency by considering the potential impact of input variances on output levels within the evaluated SUCs. Technical efficiency scores are computed under both CRS and VRS assumptions, along with scale efficiency scores for each DMU, using specific equations and constraints:

Output-orientated model (VRS)

$$Max\ \emptyset$$

Subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \le x_{i0}, \qquad i = 1,2, \ldots\ldots, m;$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \ge \emptyset y_{r0}, \qquad r = 1,2, \ldots\ldots, s;$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \ge 0 \qquad j = 1,2, \ldots \ldots, n$$

Output-orientated model (CRS)

$$Max\ \emptyset$$

Subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \le x_{i0}, \qquad i = 1,2, \ldots\ldots, m;$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \ge \emptyset y_{r0}, \qquad r = 1,2, \ldots\ldots, s;$$

$$\lambda_j \ge 0 \qquad j = 1,2, \ldots \ldots, n$$

Thanassoulis et al., (2011) provided the following equation for calculating the overall efficiency in the output-oriented framework of DMU:

$$E = \frac{1}{\emptyset}$$

However, the following ratio establishes the DMU's scale efficiency:

$$SCE = \frac{E_{CRS}}{E_{VRS}}$$

Where E_{CRS} and E_{VRS} is the efficiency score obtained under CRS and VRS, respectively.

The question of "To what extent can the quantities of inputs decrease in ratio to output quantities produced?" is important to input-oriented approach according to Coelli (1996). But the output-oriented approach seeks to answer the question, "To what extent can increased out-put quantities be proportionally accommodated without changing the amount used as input?"

The conceptual framework is designed with key components that collectively shape institutional performance. The framework, as shown in Figure 1, integrates the following essential elements:

Input parameters comprise the fundamental resources invested by HEIs, including several faculty (Full-time or Part-time, financial resources (Personnel Services, MOOE, and Capital Outlay).

The total number of academic staff and instructors at an SUC represents the number of faculty members in that institution. These include full-time faculty members, typically combining teaching, research, and administration roles, and part-time tutors handling special courses or programs. Faculty in educational institutions are critical in ensuring quality education is provided and promoting scholarship within the system, thus defining the overall effectiveness and impact of the university.

The SUC's financial resources are monetary assets that meet the organization's needs as it carries out its mandates. These consist of funds allotted to CO, MOOE, and PS. The distribution of financial resources is essential sustaining the institution's daily operations, advancing initiatives and academic programs, and developing infrastructure.

Personnel services (PS) is the term used to describe the internal management of expenditures associated with employee salaries, wages, and compensation. This crucial element benefits many individuals, including academic staff, administrative personnel, and other significant contributions. By assigning these people resources, PS makes it easier for the institution to function smoothly and provide services.

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MOOE financially supports the essential operating responsibilities of an institution. This budget covers many costs necessary for efficient operations, such as purchasing supplies, acquiring materials, and managing utilities, organizing transportation, and performing necessary repairs. MOOE ensures that all the institution's operational aspects function correctly, including upkeep of the classrooms, electricity bill management, office supply procurement, and transportation scheduling.

Strategic investments made to expand and improve an institution's infrastructure are referred to as COs. This covers the creation of infrastructure and other physical assets needed to further the institution's goal and the acquisition of machinery and other supplies. By investing in infrastructure enhancement, CO hopes to build state-of-the-art facilities tailored for research and academic endeavors, fostering an atmosphere favorable to learning and innovation. These investments support the institution's long-term survival by promoting educational excellence, enabling ground-breaking research endeavors, and fortifying the building's physical framework.

Output parameters include tangible and intangible outcomes from educational procedures, such as the number of undergraduate students, postgraduate students, and graduates.

The total number of students is an essential indicator of an SUC's student population throughout a specific period, often one academic year. This indicator represents the total number of students actively enrolled in the various educational programs offered by the school. It illustrates the school's capacity to draw in and hold on to potential students throughout their academic careers. The total number of students at SUC provides essential information on student demographics, enrollment patterns, and the demand for different educational programs. These factors all impact program development, resource allocation, and strategic planning.

On the other hand, the total number of graduates is a crucial turning point in the academic careers of SUC students. It represents the total number of individuals who have successfully finished their particular academic programs and met the graduation requirements, resulting in degrees or certifications issued by the school. This parameter is a vital indicator of the SUC's educational output and efficiency in assisting student advancement toward academic attainment and professional growth. The Total Number of Graduates highlights SUC's role in creating skilled graduates with the knowledge, skills, and competencies required for their chosen industries, contributing to workforce growth and social progress. It also gives valuable input on program success, curricular relevance, and institutional quality assurance activities, allowing for continuous adjustment and enhancement of academic offerings in response to changing student requirements and societal expectations.

Mechanisms symbolize the procedures that convert inputs into outputs and affect total efficiency. It covers techniques such as DEA for assessing efficiency, contrasting input and output metrics, and more comprehensive studies of how healthy resources are used to produce learning objectives.

Outcomes are key results of interactions between inputs, mechanisms, and outputs. Informed policy interventions, evidence-based recommendations, strategic resource optimization through efficient allocation, and continuous improvement of teaching, research, and community engagement signify positive outcomes resulting from effective HEI functioning. The study employs output-orientated CRS and VRS DEA models to provide a comprehensive assessment of technical efficiency over the period 2017-2021, providing a thorough evaluation of the efficiency dynamics within the sampled SUCs reflecting the overall.

The study utilizes MS Excel Solver Software (Cooper et al., 2007) and DEAP 2.1 (Coelli, 1996). DEAP 2.1, Microsoft Excel Solver and Data Analysis, and Microsoft Visual Basic tools for its analysis. DEAP 2.1 facilitated DEA, MS Excel Solver, and Data Analyzer provided additional analytical capabilities, and VB enabled automation and customization within Excel. These tools collectively streamlined the efficiency evaluation of SUCs, offering insights for decision-making.

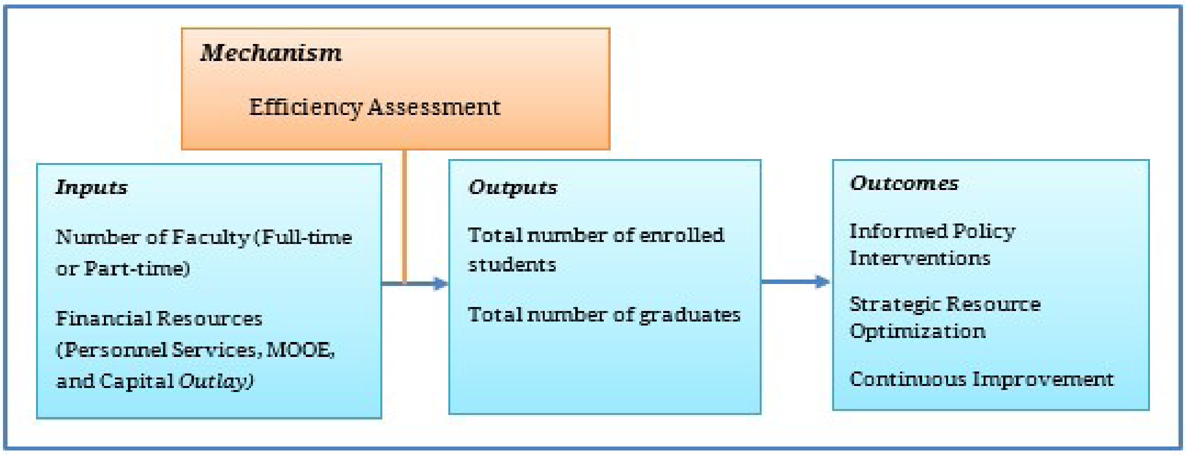

Figure 1. Schematic diagram of the study.

Figures 2 and 3 show the microsoft excel spreadsheet set-up to generate the technical efficiency and allocative efficiency scores of the SUCs. DEAP 2.1, presented in figure 4, is also used to produce other values such as the peers, slacks, and targets and the malmquist total factor productivity index of each DMU.

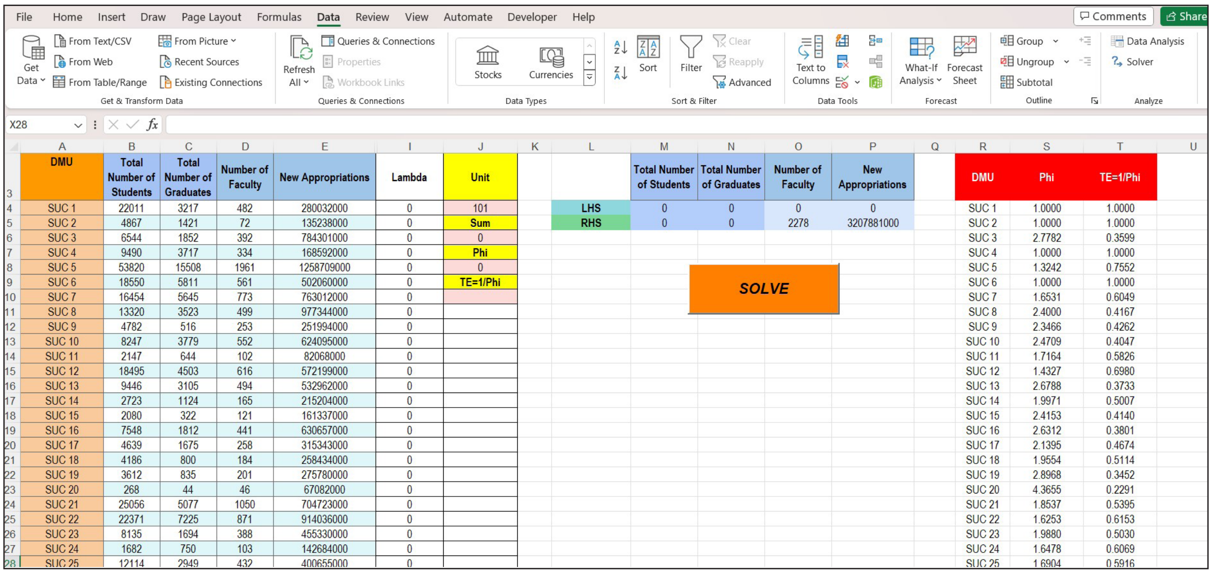

Figure 2. The Microsoft Excel spreadsheet set-up for technical efficiency.

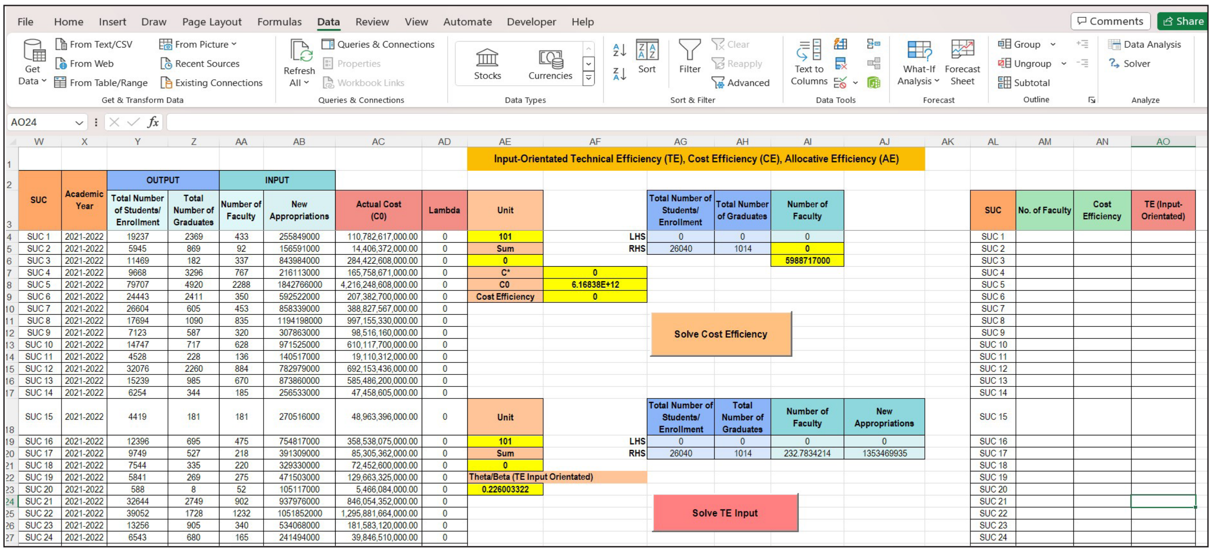

Figure 3. The Microsoft Excel spreadsheet set-up for allocative efficiency.

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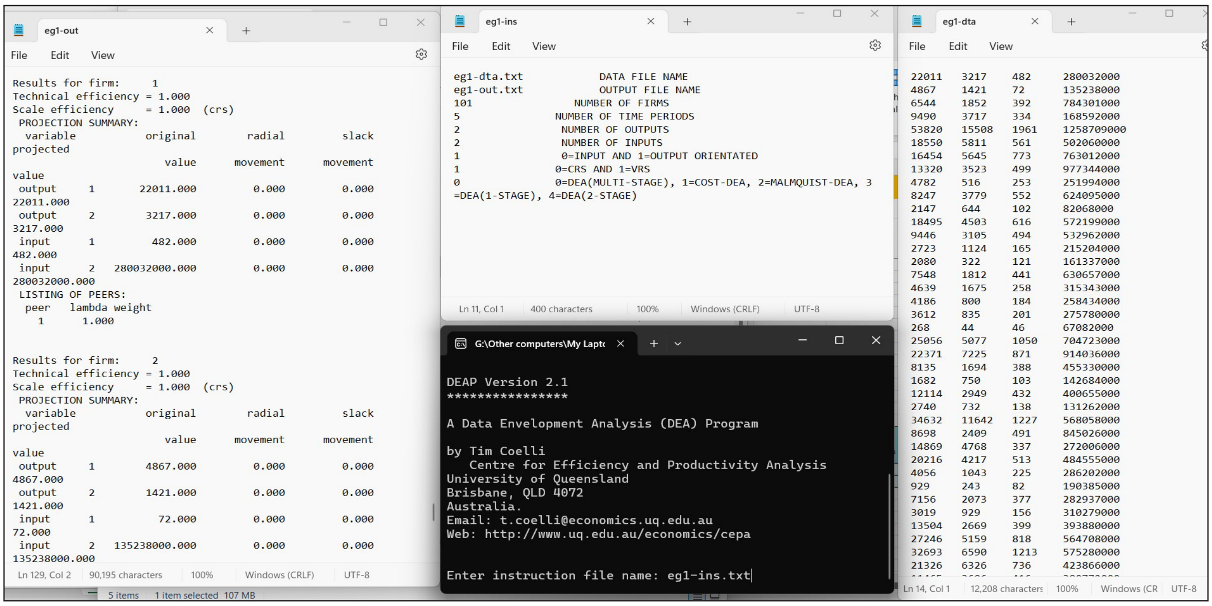

Figure 4. DEAP 2.1 Computer program.

RESULTS

Each decision-making unit (DMU) underwent assessment using output-oriented DEA with both CRS and VRS models. Scale efficiencies (SE) were also computed for each DMU. DEAP 2.1 (Coelli, 1996) and MS Excel Solver Software (Cooper et al., 2007) were used in the analysis. Notably, both software implementations produced consistent results, with congruent efficiency rankings for each entity.

Technical efficiency ratings for both CRS and VRS models of all DMUs in Luzon, Visayas, and Mindanao are delineated in Tables 4-6. DMUs attaining an efficiency score of 1 or 100% depict best practices or efficient SUCs, whereas those below 1 or 100% are deemed inefficient. Efficient SUCs based on technical efficiency under CRS and VRS assumptions are enumerated in Tables 7 and 8.

Table 4 summarizes the overall technical efficiency scores, scale efficiency, and return to scale of each SUC in Luzon from 2017 to 2021, employing both CRS and VRS assumptions. TE measures the ability of an SUC to maximize output from a given set of inputs, with a score of 1 indicating optimal efficiency. SE reflects the SUC's ability to operate at an optimal scale relative to its size, with a score of 1 indicating efficient scale utilization. Return to scale (RTS) assesses whether a SUC experiences increasing, decreasing, or constant returns to scale.

Most SUCs in Luzon exhibit varying degrees of technical inefficiency, with average TE scores of 0.52 under CRS and 0.64 under VRS assumptions, highlighting the prevalence of technical inefficiencies among Luzon SUCs. Notably, several SUCs achieve perfect efficiency scores of 1.00, including Eulogio "Amang" Rodriguez Institute of Science and Technology, Marikina Polytechnic College, Don Honorio Ventura Technological State University, Bicol University, and Camarines Sur Polytechnic Colleges, indicating optimal utilization of inputs to produce outputs. These institutions serve as beacons of efficiency, showcasing effective resource management practices and operational strategies. However, most SUCs experience technical inefficiencies, particularly under CRS assumptions, with TE scores ranging from 0.096 to 0.89. This indicates that many institutions could enhance their utilization of inputs to improve output levels further. Addressing these inefficiencies through targeted interventions could significantly enhance the overall performance and effectiveness of Luzon SUCs in fulfilling their academic missions and contributing to regional development initiatives.

SUCs have an average scale efficiency of 0.83, meaning they generally operate at around 83% of their maximum capacity. Furthermore, a thorough analysis of the dynamics of return to scale reveals a typical pattern throughout Luzon's SUCs: decreasing returns to scale. Increasing input levels may not be sufficient to cause output levels to rise correspondingly. As a result, it highlights the importance of strategically reviewing operating protocols and plans for allocating resources to boost output and steer SUCs in Luzon toward optimal performance.

Using both CRS and VRS assumptions, Table 5 shows each SUC's total TE, SE, and RTS in the Visayas from 2017 to 2021. Under CRS assumptions, the average TE scores for all SUCs in the Visayas are 0.50, while under VRS assumptions, they are 0.61. These results imply that SUCs in the Visayas are, on average, functioning at between 50% and 61% of their maximum technical efficiency, suggesting potential for improvement in output creation and resource usage. With a SE average of 0.82, SUCs in the Visayas are, on average, running at around 82% of their ideal scale efficiency.

Regarding return to scale, most SUCs in the Visayas have decreasing returns to scale, indicating that rising inputs would not always result in increasing outputs proportionately. This highlights how crucial it is to allocate resources strategically and make operational modifications to improve the performance and efficiency of SUCs in the Visayas.

Table 4. Overall technical efficiency score (CRS and VRS assumptions), scale efficiency and return to scale of each SUC in Luzon from 2017 to 2021.

State Universities and Colleges (SUCs)	**Technical Efficiency (TE)**		**Scale Efficiency (SE)**	**Return to scale**
	CRS	**VRS**	**TE(CRS)/ TE (VRS)**	
Eulogio "Amang" Rodriguez Institute of Science and Technology	**1.00**	**1.00**	**1.00**	-
Marikina Polytechnic College	**1.00**	**1.00**	**1.00**	-
Philippine Normal University	0.25	0.39	0.63	decreasing
Philippine State College of Aeronautics	0.89	0.90	0.99	increasing
Polytechnic University of the Philippines	0.68	**1.00**	0.68	decreasing
Rizal Technological University	0.71	0.92	0.78	decreasing
Technological University of the Philippines	0.47	0.67	0.70	decreasing
Don Mariano Marcos Memorial State University	0.39	0.67	0.58	decreasing
Ilocos Sur Polytechnic State College	0.36	0.38	0.94	decreasing
Mariano Marcos State University	0.39	0.57	0.68	decreasing
North Luzon Philippines State College	0.47	0.98	0.48	increasing
Pangasinan State University	0.60	0.80	0.75	decreasing
University of Northern Philippines	0.39	0.51	0.77	decreasing
Abra State Institute of Science and Technology	0.37	0.40	0.92	decreasing
Apayao State College	0.29	0.29	0.99	decreasing
Benguet State University	0.28	0.40	0.70	decreasing
Ifugao State University	0.38	0.43	0.88	decreasing
Kalinga State University	0.38	0.43	0.88	decreasing
Mountain Province State University	0.30	0.35	0.87	decreasing
Batanes State College	0.09	**1.00**	0.09	increasing
Cagayan State University	0.52	0.73	0.71	decreasing
Isabela State University	0.53	0.82	0.65	decreasing
Nueva Vizcaya State University	0.38	0.46	0.82	decreasing
Aurora State College of Technology	0.38	0.39	0.97	increasing
Bataan Peninsula State University	0.56	0.66	0.86	decreasing
Bulacan Agricultural State College	0.40	0.47	0.86	increasing
Bulacan State University	0.84	**1.00**	0.84	decreasing
Central Luzon State University	0.27	0.45	0.60	decreasing
Don Honorio Ventura Technological State University	**1.00**	**1.000**	**1.00**	-
Nueva Ecija University of Science and Technology	0.76	0.95	0.81	decreasing

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Pampanga State Agricultural University	0.32	0.37	0.86	decreasing
Philippine Merchant Marine Academy	0.17	0.17	0.96	decreasing
President Ramon Magsaysay State University	0.43	0.42	0.99	decreasing
Tarlac Agricultural University	0.30	0.37	0.80	decreasing
Tarlac State University	0.64	0.74	0.87	decreasing
Batangas State University	0.72	0.93	0.77	decreasing
Cavite State University	0.69	0.94	0.73	decreasing
Laguna State Polytechnic University	0.76	0.87	0.87	decreasing
Southern Luzon State University	0.59	0.69	0.87	decreasing
University of Rizal System	0.57	0.75	0.76	decreasing
Marinduque State University	0.40	0.41	0.97	increasing
Mindoro State University	0.56	0.58	0.96	decreasing
Occidental Mindoro State College	0.53	0.55	0.95	decreasing
Palawan State University	0.52	0.59	0.88	decreasing
Romblon State University	0.48	0.51	0.95	decreasing
Western Philippines University	0.36	0.41	0.87	decreasing
Bicol State College of Applied Sciences and Technology	0.42	0.52	0.82	decreasing
Bicol University	**1.00**	**1.00**	**1.00**	-
Camarines Norte State College	0.43	0.49	0.87	decreasing
Camarines Sur Polytechnic Colleges	**1.00**	**1.00**	**1.00**	-
Catanduanes State University	0.42	0.55	0.76	decreasing
Central Bicol State University of Agriculture	0.42	0.51	0.83	decreasing
Dr. Emilio B. Espinosa, Sr. Memorial State College of Agriculture And Technology	0.51	0.52	0.98	increasing
Partido State University	0.43	0.48	0.91	decreasing
Sorsogon State University	0.49	0.55	0.89	decreasing
Mean	**0.52**	**0.64**	**0.83**	

Table 5. Overall technical efficiency score (CRS and VRS assumptions), scale efficiency and return to scale of each SUC in Visayas from 2017 to 2021.

State Universities and Colleges (SUCs)	Technical Efficiency (TE)		Scale Efficiency (SE)	Return to scale
	CRS	VRS	TE(CRS)/ TE (VRS)	
Aklan State University	0.40	0.49	0.83	decreasing
Capiz State University	0.39	0.53	0.73	decreasing
Carlos Hilado Memorial State College	0.77	0.88	0.87	decreasing
Central Philippines State University	0.81	0.96	0.84	increasing
Guimaras State College	0.34	0.55	0.61	increasing
Iloilo Science and Technology University	0.57	0.76	0.74	decreasing
Iloilo Science and Technology University	0.68	0.76	0.89	decreasing
Northern Iloilo State University	0.44	0.52	0.85	decreasing
Northern Negros State College of Science and Technology	0.53	0.69	0.78	increasing
University of Antique	0.49	0.50	0.98	decreasing
West Visayas State University	0.37	0.63	0.58	decreasing
Bohol Island State University	0.60	0.68	0.89	decreasing
Cebu Normal University	0.55	0.67	0.82	decreasing
Cebu Technological University	0.77	**1.00**	0.77	decreasing
Siquijor State College	0.39	0.53	0.73	Increasing
Eastern Samar State University	0.47	0.56	0.84	Decreasing
Eastern Visayas State University	0.53	0.65	0.82	Decreasing
Leyte Normal University	0.34	0.36	0.93	Decreasing
Northwest Samar State University	0.61	0.66	0.93	Decreasing
Palompon Institute of Technology	0.35	0.38	0.94	Decreasing
Samar State University	0.41	0.44	0.92	Decreasing
Southern Leyte State University	0.45	0.47	0.96	Decreasing
University of Eastern Philippines	0.46	0.57	0.81	Decreasing
Visayas State University	0.31	0.45	0.69	Decreasing
Mean	**0.50**	**0.61**	**0.82**	

Table 6. Overall technical efficiency score (CRS and VRS assumptions), scale efficiency and return to scale of each SUC in Mindanao from 2017 to 2021.

State Universities and Colleges (SUCs)	Technical Efficiency (TE)		Scale Efficiency (SE)	Return to scale
	CRS	VRS	TE(CRS)/ TE (VRS)	
Jose Rizal Memorial State University	0.47	0.55	0.86	decreasing
Western Mindanao State University	0.49	0.7	0.66	decreasing
Zamboanga Peninsula Polytechnic State University	0.45	0.46	0.99	increasing
Zamboanga State College of Marine Sciences and Technology	0.49	0.54	0.91	decreasing
Bukidnon State University	0.48	0.52	0.93	decreasing
Camiguin Polytechnic State College	0.44	0.47	0.93	increasing
Central Mindanao University	0.31	0.43	0.71	decreasing
Northwestern Mindanao State College of Science and Technology	0.29	**1.00**	0.29	increasing
University of Science and Technology of Southern Philippines	0.39	0.44	0.89	decreasing
Davao de Oro State College	0.57	0.85	0.67	increasing
Davao del Norte State College	0.31	0.31	0.99	decreasing
Davao Oriental State University	0.75	0.75	0.99	increasing
Southern Philippines Agri-business and Marine and Aquatic School of Technology	0.38	0.43	0.89	increasing
University of Southeastern Philippines	0.64	0.92	0.69	decreasing
Cotabato Foundation College of Science And Technology	0.62	0.63	0.99	increasing
Sultan Kudarat State University	0.66	0.66	0.99	decreasing
University of Southern Mindanao	0.41	0.58	0.71	decreasing
Agusan del Sur State College of Agriculture and Technology	0.46	0.49	0.93	increasing
Caraga State University	0.37	0.39	0.97	decreasing
Surigao State College of Technology	0.58	0.64	0.91	decreasing
Cotabato State University	**1.00**	**1.00**	**1.00**	-
Mindanao State University	0.33	0.84	0.39	decreasing
Mean	**0.49**	**0.62**	**0.83**	

Table 6 provides an overall TE, SE, and RTS of each SUC in Mindanao from 2017 to 2021, considering both CRS and VRS assumptions. The analysis reveals that the mean technical efficiency scores for SUCs in Mindanao are 0.49 under CRS and 0.62 under VRS assumptions. Notably, Cotabato State University achieves perfect efficiency scores of 1.00, indicating optimal utilization of inputs to produce outputs. However, other SUCs exhibit varying technical inefficiency, with TE scores ranging from 0.29 to 0.75 under CRS assumptions. Scale efficiency across Mindanao SUCs has a mean score of 0.83, suggesting that, on average, these institutions operate at approximately 83% of their optimal scale.

Furthermore, the analysis of return to scale reveals that most SUCs in Mindanao experience decreasing returns to scale, implying that increasing input levels may not proportionally increase output levels. However, some SUCs, such as Zamboanga Peninsula Polytechnic State University, Camiguin Polytechnic State College, and Davao Oriental State University, exhibit increasing returns to scale, indicating potential opportunities for further expansion and resource utilization efficiency. These insights underscore the need for strategic resource management and operational adjustments to enhance efficiency and performance among SUCs in Mindanao.

Tables 7 highlight the SUCs demonstrating efficient performance based on DEA Technical Efficiency results under the CRS and VRS assumptions from 2017 to 2022. These efficient SUCs are identified as institutions that have effectively utilized their inputs to maximize outputs within the given period.

These efficient SUCs serve as benchmarks for other institutions in the higher education sector, highlighting best practices and successful strategies in resource management, teaching, research, and other areas. By studying and emulating the practices of these efficient SUCs, other institutions can strive to enhance their operational performance and contribute more effectively to the academic and societal objectives they serve.

Table 7. Efficient state universities and colleges (SUCs) based on DEA technical efficiency results under CRS assumption (2017-2022).

Eulogio"Amang" Rodriguez Institute of Science and Technology
Marikina Polytechtnic College
Don Honorio Ventura Technological State University
Bicol University
Camarines Sur Polytechnic Colleges
Cotabato State University
Efficient SUCs based on DEA technical efficiency results under VRS assumption (2017-2022)
Eulogio "Amang" Rodriguez Institute of Science and Technology
Marikina Polytechnic College
Polytechnic University of the Philippines
Batanes State College
Bulacan State University
Don Honorio Ventura Technological State University
Bicol University
Camarines Sur Polytechnic Colleges
Cebu Technological University
Northwestern Mindanao State College of Science and Technology
Cotabato State University

DISCUSSION

Several key insights emerge from the comprehensive analysis of SUCs across Luzon, Visayas, Mindanao, and the Philippines. The tables provided, encompassing technical efficiency, scale efficiency, and return-to-scale metrics under both CRS and VRS assumptions, offer valuable insights into the operational performance of these institutions from 2017 to 2021.

While a few SUCs in Luzon have perfect scores of 1.00, which indicate ideal resource usage and product generation, the bulk shows various degrees of technical inefficiency. Remarkably, establishments like Don Honorio Ventura Technological State University, Eulogio “Amang” Rodriguez Institute of Science and Technology, and Marikina Polytechnic College demonstrate efficient resource management techniques. Focused interventions are necessary to increase resource utilization and operational performance among Luzon SUCs, as evidenced by technical inefficiencies, especially when considering CRS assumptions. The CRS model tends to lower the efficiency score, while the VRS model tends to raise the efficiency score (Dagaraga, 2016).

Similar trends are seen in the Visayas, where SUCs typically run between 50% and 61% of their maximum technical efficiency. While a few institutions attain efficiency ratings of 1.00, the majority face diminishing returns to size, underscoring the significance of strategically allocating resources to improve performance and efficiency.

According to CRS assumptions, the analysis finds that Mindanao has a mean technical efficiency score of 0.49, whereas, under VRS assumptions, it is 0.62. Some universities show varied degrees of technical inefficiency, but Cotabato State University distinguishes out with flawless efficiency rankings. Given the general trend of declining returns to scale, strategic resource management is necessary to maximize operational performance.

The study highlights significant differences in technical inefficiency between SUCs in various Philippine regions; under multiple assumptions, average technical efficiency scores range from roughly 50% to 63%. Although some organizations use their resources well, many need more efficiency, especially regarding resource distribution and operating procedures. Scale efficiency insights show that SUCs typically run at about 83% of their ideal scale, suggesting that operational scaling can still be improved. Further evidence that raising input levels might not translate into output gains commensurate with them comes from the fact that most SUCs face declining returns to scale. Strategic planning is essential to improve the efficiency and efficacy of providing high-quality education and promoting regional development, as this profound grasp of technological and scale efficiencies highlights.

The results corroborate other research, including Cuenca (2011), which found few effective SUCs and highlighted the ongoing problem of inefficiency in the higher education sector. Acodile-Viado and Namoco (2020) state that prompt corrective measures are essential for improving the performance of less effective SUCs and fostering significant gains in overall institutional effectiveness, which will enhance the Philippines' higher education system.

Hernandez-Balderrama et al. (2016) evaluated 40 higher education institutions (HEIs) in Mexico using DEA, focusing on teaching, research, and knowledge dissemination. Their findings categorized HEIs as technically efficient or inefficient, highlighting areas for improvement. Similarly, Salas-Velasco and Salas-Velasco (2020) emphasized DEA's role as a benchmarking tool for assessing universities' technical efficiency, using Spanish public universities as a case study. They found an average efficiency rate of 92% and noted that higher grant percentages reduced inefficiency, while tenured academics boosted productivity. DEA-derived rankings aligned closely with established university rankings.

Additionally, Visbal-Cadavid et al. (2017) assessed the efficiency of Colombian public universities using DEA, identifying top performers and areas for improvement among inefficient HEIs. Their analysis using the Malmquist index showed significant improvements in technical efficiency for some universities from 2011 to 2012. A San Pedro College study evaluated six colleges' technical efficiency from 2004 to 2014, revealing varying efficiency levels across departments. While some departments maintained technical efficiency, others fell short in specific years. Similarly,Fernando and Cabanda (2007) evaluated 13 colleges atthe University of Santo Tomas (UST) using Malmquist indices and DEA, finding efficient operations but declining technological progress. Their analysis highlighted technical efficiency over innovation, providing insights into efficiency and productivity in higher education.

Efficient SUCs identified across the Philippines serve as benchmarks for best practices, offering insights into effective resource utilization, teaching quality, research output, and overall institutional effectiveness. By studying and emulating these efficient SUCs, other institutions can enhance their operational performance and contribute more effectively to academic and societal objectives. Considering the constraints of limited government resources, it is imperative to ensure their optimal utilization to accomplish their intended objectives effectively. However, an inevitable waste of limited resources occurs, particularly when institutions like SUCs do not meet goals. Therefore, it is essential to recognize, understand, and resolve the factors that influence the performance of SUCs (Cuenca, 2011). Overall, the findings underscore the importance of evidence-based policymaking and strategic resource management in the higher education sector to drive efficiency, excellence, and impact across diverse regions of the Philippines.

CONCLUSION

A detailed evaluation of SUCs in the Philippines between 2017 and 2021 revealed a varied picture of technical efficiency, scale efficiency, and return to scale. Several institutions employ their resources effectively and provide high-quality products, while others have inefficiencies that indicate areas where operational performance might be improved. Identifying effective SUCs in these regions offers valuable best-practice insights and helps enhance operational performance and meet societal and academic objectives.

The government must create and put into effect policies that give institutional governance, capacity building within SUCs, and resource allocation priority. The goals of these rules are to reward productivity increases, support accountability and openness in the use of resources, and stimulate creativity in teaching and research. Fostering cooperation between SUCs and business partners should also be a priority to guarantee that academic offerings align with industrial demands. SUCs should invest in continuous professional development programs for their professors and staff to improve their capacity for teaching and research. Initiatives to update technology and modernize infrastructure are also necessary to support digital learning and administrative procedures. In order to guarantee that students have access to the tools and support they need to excel academically, SUCs should also prioritize student support services.

Long-term studies are necessary for future research to monitor the effects of institutional reforms and policy initiatives on the productivity and efficiency of SUCs across time. Furthermore, comparison analyses with global standards may provide further insights into optimal higher education administration and coordination approaches. To improve the performance of SUCs and guarantee their continuous contribution to national development, a multifaceted strategy, including capacity training, policy reforms, and strategic investments, is necessary.

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