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Efficiency and productivity indices of university academic units: A case of a Philippine autonomous university

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ABSTRACT

This study employs Data Envelopment Analysis (DEA) to assess the technical efficiency of various academic units at the University of Mindanao, specifically examining the performance of its colleges and branch campuses in utilizing resources to maximize educational and research outputs. The evaluation considers key input variables such as faculty numbers, budget allocations, and student enrollment, while outputs include graduation rates, publication counts, and community engagement initiatives. The results reveal significant variations in efficiency among academic units. The College of Engineering consistently demonstrate high efficiency scores, effectively optimizing resources to produce strong academic outputs. In contrast, some branch campuses exhibit lower efficiency due to constraints in faculty expertise, limited research activities, and underutilized financial resources. Additionally, the study applies the Malmquist Productivity Index to track efficiency changes over time, revealing that colleges with strong faculty development programs and strategic funding allocation—such as the College of Arts and Sciences Education—show sustained or improving efficiency trends. Meanwhile, units with slower adaptation to technological and pedagogical advancements struggle to maintain productivity. These findings provide valuable insights for university administrators and policymakers, enabling them to refine resource distribution, strengthen faculty development, and implement targeted interventions to enhance institutional effectiveness.

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1. INTRODUCTION

The global pandemic has exacerbated financial challenges among students, resulting in scarce resources for both individuals and institutions. In light of these constraints, the efficient management of limited resources has become a central issue for educational institutions (Toquero, 2020). Organizations across sectors—both profit and non-profit, as well as public and private—are

adopting various strategies to maximize output from minimal inputs. Moreover, these organizations are employing different methods to assess their operational efficiency, striving to identify inefficiencies and improve their processes (Mikušová, 2017; Taylor, 2017). Such practices are increasingly critical in higher education, where resource optimization directly affects institutional sustainability and academic performance.

The notion of inefficiency in the education sector, particularly in higher education, has been widely recognized in the literature (Gralka, Wohlrabe & Bornmann, 2019; Cunha & Rocha, 2012; Yang, Fukuyama & Song, 2018). Policymakers and institutional administrators view good performance in higher education as a catalyst for economic growth and societal development (Blanchard, 2004). As a result, numerous empirical studies (e.g., Duan, 2019; Martínez-Campillo & Fernández-Santos, 2020; Rostamzadeh et al., 2021) have sought to identify efficient institutions and benchmark them against their less efficient counterparts. Measuring institutional efficiency serves as a foundational step for implementing, monitoring, and evaluating public-sector reforms. By understanding efficiency levels, institutions can better align their resource allocation with performance goals, ensuring the best possible outcomes.

Classical microeconomic theory typically assumes homogeneity among firms, suggesting that all entities operate at similar levels of productivity or technical efficiency. However, empirical evidence challenges this notion, revealing significant disparities in efficiency across organizations (Dunlop, 1992). In practice, some institutions operate at the technological frontier, maximizing their resources and achieving high productivity, while others struggle to sustain operations. This disparity is particularly evident in higher education, where financial stringency and the increasing demand for accountability and cost-effectiveness have intensified the need for resource optimization (Tran et al., 2023). Institutions are now under growing pressure to diversify funding sources and demonstrate measurable efficiency in their operations.

Looking at the perspective of a Philippine university with autonomous status, the efficient use of resources is a critical concern. Each college of universities in the Philippines usually operate with an annual budget allocated by the university's management, which is utilized according to an annual operations plan. The goal is to achieve technical efficiency by maximizing outputs within the constraints of available inputs. However, the recent decline in student enrollment has made achieving efficiency increasingly challenging. This situation underscores the relevance and urgency of conducting a technical efficiency analysis to assess how effectively the university's academic departments utilize their resources and identify areas for improvement.

The efficiency of academic departments in higher education institutions has been extensively explored in the literature, as it directly impacts institutional success and societal development. Inputs in higher education, such as budget allocations, staffing, and faculty qualifications, are critical for determining the efficiency of academic departments. Budgeting in higher education, often described as a financial representation of an institution's goals and priorities, plays a vital role in resource allocation. Studies have emphasized that well-planned budgets enable departments to meet their objectives effectively by enhancing coordination among stakeholders and promoting commitment to institutional missions (Ogungbenle & Edogiawerie 2016; Xu et al. 2017). Moreover, non-teaching staff, often overlooked in efficiency assessments, provide essential support for administrative and operational functions, ensuring the smooth running of institutions. Studies have highlighted that collaborative relationships between teaching and non-teaching staff enhance overall productivity and the quality of student outcomes (Garcia, Sadang, & Hernandez, 2019; Gono, 2018).

With the increasing emphasis on accountability and cost-effectiveness in higher education, institutions must strategically manage their resources to maintain high performance (Bucăţa & Tileagă, 2023; George & Wooden, 2023). The inclusion of faculty credentials, particularly the proportion of staff with PhDs, acknowledges the significance of academic qualifications in influencing research productivity and instructional quality. A well-credentialed faculty is often linked to stronger research output, higher student success rates, and greater institutional impact (Bastian, Lys & Whisenant, 2023; Graham & Flamini, 2023; Taylor, 2017). Similarly, total enrollment is considered an essential input, as student numbers determine workload distribution, resource allocation, and overall

academic efficiency (Mikušová, 2017; Yee & Yee, 2023). Ensuring that faculty expertise, financial resources, and student engagement contribute effectively to institutional outputs is central to achieving technical efficiency.

Despite the extensive research, significant gaps remain in the literature. One limitation is the lack of a standardized framework for measuring efficiency across institutions, as methodologies often vary based on contextual factors such as region, funding structures, and institutional priorities. Additionally, the over-reliance on quantitative metrics, such as publication counts and enrollment rates, may overlook qualitative aspects, such as faculty-student interactions and the long-term societal impact of community extension programs. Future research should aim to integrate these qualitative dimensions into efficiency assessments and explore innovative approaches to resource allocation that address the unique challenges of higher education institutions in different contexts.

This study aims to evaluate the technical efficiency of academic departments at the University of Mindanao using data envelopment analysis (DEA). Specifically, it seeks to examine the operational profiles of these departments in terms of inputs, such as the annual budget, teaching staff, proportion of PhD holders to total teaching staff and total enrollment, and outputs, including approved or ongoing institutional research, faculty participation in community extension activities, research publications, and total graduates. Additionally, the study will calculate the technical efficiency scores of the departments over three years and identify which academic units have demonstrated productivity improvements during this period. This comprehensive analysis will provide valuable insights for optimizing resource allocation and enhancing institutional performance.

2. RESEARCH METHOD

2.1 Research Design

The study employed an econometric approach, specifically Data Envelopment Analysis (DEA), to assess the technical efficiency of academic departments at the University of Mindanao. DEA provided a comparative measure of efficiency by analyzing single input-output relationships as well as multiple inputs and outputs within decision-making units (DMUs). By restricting weights, DEA defined efficiency as the ratio of the weighted sum of outputs to the weighted sum of inputs, allowing for the identification of relative efficiency among academic units (Talluri, 2000). Two general methodologies were considered in efficiency measurement—the mathematical programming approach and the econometric approach. DEA, which belonged to the mathematical programming approach, was selected for this study due to its established application in evaluating the efficiency of institutions with multiple input-output relationships.

2.2 Data and Data Sources

This study utilized secondary data, with input-output specifications for technical and cost efficiency derived from reports spanning 2018 to 2020 from multiple administrative offices of the University of Mindanao, including the Treasury, Records and Admission, Academic Planning, Research and Publication, and PakiglaUM/Community Extension. These records covered efficiency indicators for colleges and branches, ensuring a comprehensive assessment of their performance over three years. The inclusion of multiple years allowed for the identification of trends, variations, and improvements in the efficiency of academic units over time.

Table 1. *Input-output specification*

Inputs	Outputs
• Annual budget • Number of non-teaching staff • Proportion of faculty members with doctoral degrees to total teaching staff • Total enrollment	• Number of approved/ongoing institutional research • Number of faculty members who participated in community extension activities • Number of research publications • Total graduates

The selection of inputs and outputs was informed by existing literature and previous studies, which have established standard variables used in efficiency analysis across different applications and methodologies. The study employed both input- and output-oriented data envelopment analysis (DEA) models under the assumptions of constant returns-to-scale (CRS) and variable returns-to-scale (VRS). The input-oriented model focused on minimizing input use while maintaining output levels, while the output-oriented model emphasized maximizing outputs given available resources (Charnes, Cooper & Rhodes, 1978). Both models provided a holistic evaluation of the efficiency of academic units in utilizing resources to achieve institutional goals.

To ensure the validity of the DEA model, the study considered the positivity and isotonicity properties in its specification. Positivity ensured that all inputs and outputs had values greater than zero, confirming that each variable contributed meaningfully to the efficiency assessment. Meanwhile, isotonicity established that an increase in inputs should, in some way, lead to an increase in outputs, a fundamental assumption in efficiency measurement (Bowlin, 1998). By adhering to these principles, the study provided a robust and theoretically sound evaluation of the technical efficiency of academic units within the university.

2.3 Data Collection Procedure

Before proceeding with data collection, the researcher, under the guidance of the research supervisor, sought formal approval from the Dean of Professional Schools of the University of Mindanao. A request was also submitted to the President/COO of the University of Mindanao for authorization to conduct a performance evaluation of its colleges and branches. These steps were carried out in accordance with the institutional ethical review process, requiring prior approval from the UM Ethics Review Committee before data collection commenced.

Upon securing the necessary approvals, the researcher gathered available secondary data from institutional reports covering five school years. Reports were collected, organized, and encoded from the relevant offices, including Treasury, Records and Admission, Academic Planning, Research and Publication, and Community Extension (PakiglaUM). The preparation of datasets from secondary sources was planned for March 2021, contingent upon approval from the university's management. Data from each year were compiled, profiled, and structured to facilitate the efficiency analysis.

Following data compilation, a summary report was generated, detailing the inputs and outputs for both technical efficiency models. The dataset was subsequently transferred into DEAP 2.1 software, which was utilized for DEA estimations (Coelli, 1996). In the software, commands were specified in the instruction file, allowing for the systematic processing of the data and the generation of efficiency scores. DEA efficiency scores were interpreted based on a benchmark of one, where a DMU that achieved a score of 1.00 was considered fully technically efficient, while any score below 1.00 indicated inefficiency in resource utilization. To assess efficiency variations over time, Malmquist DEA productivity indices change analysis was incorporated into the study. This measure enabled the study to determine relative changes in technical efficiency scores across different years, providing insights into whether academic departments demonstrated improvement, stagnation, or decline in performance over time.

2.4 Ethical Considerations

The study observed full ethical standards in administering the study and underwent examination and approval from the University of Mindanao Ethics Review Committee (UMERC) with approval number 2021-165.

3. RESULTS AND DISCUSSIONS

3.1. Descriptive Statistics of University Academic Departments

The following discussions focused on the descriptive analysis of the inputs and outputs of various academic departments of an autonomous Philippine university (i.e., University of Mindanao in Davao City) from 2018 to 2020. The results provide insights into the relative performance, resource allocation, and output generation of each department, revealing patterns of efficiency and variation across academic units.

The number of graduates varied significantly across academic departments, with Tagum campus producing the highest average graduates ($\bar{x}$ = 1,391, SD = 29.4), followed by College of Business Administration Education ($\bar{x}$ = 627, SD = 113) and Digos campus ($\bar{x}$ = 512, SD = 15.0). In contrast, the College of Legal Education had the lowest number of graduates, with an average of $\bar{x}$ = 14 (SD = 1.73). This variation reflects differences in program offerings, student retention rates, and program demand across academic units. Similarly, total enrollment figures showed substantial variability, with Tagum campus recording the highest student enrollment ($\bar{x}$ = 17,772, SD = 1,765), while CLE had the lowest ($\bar{x}$ = 227, SD = 202). The disparity suggests that some colleges cater to more extensive academic programs, while others serve more specialized fields with limited student intake.

The number of approved or ongoing institutional research projects also exhibited notable disparities. The College of Engineering Education (CEE) reported the highest research activity ($\bar{x}$ = 17.3, SD = 18.0), followed by College of Computing Education ($\bar{x}$ = 13.3, SD = 4.04) and College of Arts and Sciences Education ($\bar{x}$ = 11.3, SD = 13.6). Several departments, including UM Bansalan, UM Panabo, and CLE, reported no institutional research output during the period. This highlights a significant gap in research productivity across departments, where some units actively engage in institutional research while others lag. Similarly, research publication output was highest for CASE ($\bar{x}$ = 33.3, SD = 3.79) and CCE ($\bar{x}$ = 28.7, SD = 41.9), demonstrating strong research engagement. Conversely, colleges such as College of Health Sciences Education, reported minimal research publication outputs. These findings suggest that research output is concentrated in certain academic units, potentially influenced by faculty research culture, funding availability, and institutional research priorities.

Faculty participation in community extension activities was another indicator of output efficiency. The Tagum campus exhibited the highest engagement ($\bar{x}$ = 310, SD = 168), far exceeding other departments. This trend suggests that large satellite campuses may have more extensive outreach initiatives and partnerships with local communities. Meanwhile, Colleges of Legal Education, Health Sciences Education, and Architecture and Fine Arts Education reported some of the lowest participation rates, implying lower faculty engagement in external initiatives. Given that community extension activities contribute to societal impact and institutional performance rankings, these findings emphasize the need for improvement in faculty participation across certain departments.

Budget allocations varied considerably, with Tagum campus receiving the highest funding, followed by Digos and CEE. In contrast, CLE had the lowest budget allocation. The difference in budgetary resources may correlate with enrollment size, research activity, and program offerings. The number of teaching staff was also highest for Tagum ($\bar{x}$ = 209, SD = 20.6) and Professional Schools ($\bar{x}$ = 163, SD = 15.0), while the lowest was observed in CHSE ($\bar{x}$ = 14.3, SD = 6.11). These figures indicate that larger colleges tend to have higher faculty counts, reflecting student-teacher ratios and instructional demand. Meanwhile, the proportion of faculty with doctoral degrees was highest in Professional Schools ($\bar{x}$ = 69.7, SD = 3.95), followed by CCJE ($\bar{x}$ = 32.4, SD = 3.46) and CEE ($\bar{x}$ = 14.7, SD = 15.4). Some departments, including Bansalan, CHSE, CLE, and CAFAE, reported no faculty members with doctoral qualifications. This finding highlights disparities in faculty qualifications, which may impact teaching quality, research productivity, and accreditation performance. Colleges with a higher proportion of doctoral degree holders are expected to exhibit stronger research engagement and academic leadership.

3.2. Technical Efficiency of the University Academic Units

The technical efficiency results based on the input-oriented Malmquist Data Envelopment Analysis (DEA) for the 16 academic units of the University of Mindanao are presented across three years (2018–2020). Table 2 displays the constant returns to scale (CRS) technical efficiency relative to technology in each year, as well as variable returns to scale (VRS) efficiency scores. The results indicate that several academic units, such as CAE, CASE, and CHSE, consistently maintain full efficiency (CRS TE = 1.000) across all three years. However, some units show inefficiency in specific years, such as CEE in 2018 (CRS TE = 0.644) and CLE in 2020 (CRS TE = 0.476). Additionally, Panabo and Bansalan exhibited fluctuations in efficiency across the three-year period. These variations suggest that some units struggle to optimize their input usage in certain years, potentially due to changes in faculty

Table 2. *Distance functions for academic units (2018-2020)*

Academic Unit	Constant Returns-to-Scale (CRS) Assumption			Variable Returns-to-Scale (VRS) Assumption		
	2018	2019	2020	2018	2019	2020
CAE	1.000	1.000	1.000	1.000	1.000	1.000
CAFAE	1.000	1.000	0.686	1.000	1.000	0.881
CASE	1.000	1.000	1.000	1.000	1.000	1.000
CBAE	0.989	1.000	1.000	1.000	1.000	1.000
CCE	1.000	1.000	1.000	1.000	1.000	1.000
CCJE	1.000	1.000	1.000	1.000	1.000	1.000
CEE	0.644	1.000	0.978	0.654	1.000	1.000
CHE	0.992	1.000	0.853	1.000	1.000	0.943
CHSE	1.000	1.000	1.000	1.000	1.000	1.000
CTE	0.813	0.801	0.876	0.821	0.833	0.879
CLE	1.000	1.000	0.476	1.000	1.000	1.000
PS	1.000	0.392	0.949	1.000	0.526	1.000
Tagum	0.839	1.000	1.000	1.000	1.000	1.000
Panabo	0.989	0.738	1.000	1.000	0.757	1.000
Bansalan	1.000	0.946	1.000	1.000	1.000	1.000
Digos	0.610	0.479	0.826	0.712	0.485	0.860

composition, funding, or research productivity.

With these results, the study surmised that several colleges exhibited consistent technical efficiency across the three-year period, maintaining a CRS TE score of 1.000. These include CAE, CASE, CHSE, CCE, and CHSE, which maintained full efficiency in all years. The sustained high efficiency of these units suggests that they effectively utilize their allocated resources, particularly in faculty staffing, budget allocation, and research productivity. These colleges likely benefit from a combination of well-managed academic operations, faculty development initiatives, and robust student enrollment, ensuring that inputs are effectively converted into academic outputs such as research publications, institutional projects, and graduate production. Additionally, Tagum (TFPCH = 1.450) exhibited the highest total factor productivity change (TFPCH), indicating significant improvements in efficiency and technological advancements. This suggests that the Tagum campus may have benefited from infrastructure investments, faculty hiring, or research capacity-building initiatives that contributed to a sustained increase in performance over the years. In contrast, some colleges exhibited lower technical efficiency and declining productivity, particularly in specific years. The CLE (TFPCH = 0.460) and CCE (TFPCH = 0.449) recorded the lowest productivity scores across the period, indicating persistent inefficiencies. This suggests that these units may struggle with resource utilization, potentially due to a limited number of research-active faculty, a lower proportion of doctoral degree holders, or challenges in securing research funding.

Another concern is the fluctuating efficiency of Digos and Panabo, where significant drops in technical efficiency were observed in certain years. The inefficiencies in these UM branches could be attributed to variations in student enrollment, limited research output, or budget constraints affecting faculty development programs. The CLE (TFPCH = 0.460), in particular, may have faced challenges in sustaining research productivity or community extension initiatives, which are key output indicators in the analysis.

Moving on, results from the Malmquist Index measures changes in productivity over time, decomposing it into efficiency change (EFFCH), technological change (TECHCH), pure efficiency change (PECH), and scale efficiency change (SECH). Table 3 provides the summary of Malmquist

Table 3. *Malmquist Index Summary (2018–2020)*

Year	Efficiency Change (effch)	Technological Change (techch)	Pure Efficiency Change (pech)	Scale Efficiency Change (sech)	Total Factor Productivity Change (tfpch)
2018–2019	0.945	1.124	0.947	0.997	1.062
2019–2020	1.037	0.681	1.089	0.952	0.706
Mean	0.990	0.875	1.016	0.975	0.866

productivity changes across the two periods. From 2018 to 2019, there was an increase in total factor productivity (TFPCH = 1.062), driven primarily by technological progress (TECHCH = 1.124). However, in the subsequent period (2019–2020), there was a decline in total factor productivity (TFPCH = 0.706), which can be attributed to a significant drop in technological change (TECHCH = 0.681). This suggests that while the academic units initially improved in productivity, possibly due to advancements in research output or faculty development, they later experienced a slowdown in technological progress, potentially due to external constraints such as budget limitations or pandemic-related disruptions.

Meanwhile, Table 4 provides the average Malmquist Index scores across academic units, highlighting differences in productivity performance. The results indicate significant variations in productivity performance among academic units. Tagum performed the best in total factor productivity change (TFPCH = 1.450), suggesting strong technological improvements. In contrast, CCE and CLE exhibited the lowest productivity scores (TFPCH = 0.449 and 0.460, respectively), highlighting inefficiencies and potential areas for improvement.

Table 5. *Malmquist Index Summary by Academic Unit (2018–2020)*

Academic Unit	Efficiency Change (effch)	Technological Change (techch)	Pure Efficiency Change (pech)	Scale Efficiency Change (sech)	Total Factor Productivity Change (tfpch)
CAE	1.000	1.066	1.000	1.000	1.066
CAFAE	0.828	1.213	0.939	0.882	1.005
CASE	1.000	0.824	1.000	1.000	0.824
CBAE	1.006	1.019	1.000	1.006	1.024
CCE	1.000	0.449	1.000	1.000	0.449
CCJE	1.000	0.788	1.000	1.000	0.788
CEE	1.232	1.079	1.237	0.996	1.330
CHE	0.927	0.957	0.971	0.955	0.888
CHSE	1.000	1.099	1.000	1.000	1.099
CTE	1.038	0.884	1.034	1.003	0.918
CLE	0.690	0.667	1.000	0.690	0.460
PS	0.974	0.564	1.000	0.974	0.550
Tagum	1.092	1.328	1.000	1.092	1.450
Panabo	1.005	0.800	1.000	1.005	0.805
Bansalan	1.000	1.017	1.000	1.000	1.017
Digos	1.163	0.749	1.099	1.058	0.871

The results highlight the varying degrees of technical efficiency among the academic units of the University of Mindanao. While some colleges consistently demonstrate optimal performance, others exhibit inefficiencies. The efficiency of academic units is likely influenced by a combination of factors, including the proportion of faculty with doctoral degrees, the availability of institutional research grants, and the capacity for community engagement. Colleges with strong faculty research participation and consistent publication output appear to maintain high technical efficiency. On the other hand, inefficiencies may stem from low research engagement, faculty constraints, or declining enrollment trends, which impact resource allocation and institutional performance.

4. CONCLUSION

Descriptive analysis revealed significant variability in the factor inputs and outputs among the academic units. Colleges like UM Tagum, with the largest budget allocation and the highest enrollment and graduate numbers, exhibited notable strengths in resource utilization. Similarly, CASE and CCE recorded strong research engagement, as reflected in their high number of research publications and institutional research projects. On the other hand, CLE, CHSE, and UM Panabo consistently exhibited lower performance in key output indicators, such as research publications and community extension participation, which contributed to their inefficiencies. Additionally, CLE reported the smallest budget allocation, the lowest graduate numbers, and a lack of faculty members with doctoral degrees, further highlighting the constraints faced by this unit in achieving technical efficiency.

The study further revealed significant variations in technical efficiency across the 16 academic departments from 2018 to 2020. Several academic units, such as CAE, CASE, CCE, and CHSE, consistently demonstrated full efficiency, achieving optimal utilization of their resources to maximize outputs such as research publications, community engagement, and graduate production. These efficient units are characterized by strong faculty research participation, robust academic management, and alignment between resources and institutional goals.

In contrast, some units, such as CLE and CCE, exhibited persistent inefficiencies and low productivity scores. These inefficiencies were primarily attributed to limited research productivity, lower faculty qualifications, and restricted community engagement. Additionally, fluctuations in efficiency were observed in UM branches like Digos and Panabo, suggesting challenges in resource allocation and adapting to changing enrollment trends. While technological advancements contributed to improvements in total factor productivity from 2018 to 2019, there was a noticeable decline in productivity from 2019 to 2020, likely due to disruptions caused by the pandemic and external constraints.

Finally, the study highlighted the significant role of resource optimization, faculty development, and technological investment in driving institutional performance. The findings underscore the need for targeted interventions to address inefficiencies while leveraging the best practices of high-performing units to enhance the overall effectiveness of the university's academic operations.

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