



MEASURING EFFICIENCY IN AZERBAIJAN'S HIGHER EDUCATION SYSTEM THROUGH STATISTICAL AND COMPOSITE INDEX APPROACHES

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Abstract

This article examines the assessment of economic efficiency in Azerbaijan's higher education system within the context of modern education policy and management. The efficient use of resources by higher education institutions and the effectiveness of achieved results directly impact the country's economic development. In this framework, multidimensional statistical methods and composite index approaches are applied to measure higher education system efficiency. These approaches enable comprehensive evaluation of educational institutions' internal and external performance by integrating various indicators into a unified system. The application of these methods in Azerbaijan is important for formulating development strategies in the education sector and for optimal resource allocation. The main purpose of the article is to examine the relationship between higher education institutions' resource use and outcomes on a scientific basis, analyze existing methodologies, and present an evaluation model appropriate to the local context. This research will serve as a useful tool in the decision-making process for both education policymakers and administrators.

Keywords: *Higher education efficiency, Composite indices, Statistical methods, Data Envelopment Analysis (DEA), Education policy and management*

Introduction

The evaluation of the economic efficiency of the higher education system is one of the key issues in modern education policy and management. Efficient use of resources by educational institutions and the effectiveness of the results achieved directly impact the country's economic development. Especially in a globalizing world and rapidly changing socio-economic conditions, precise and comprehensive assessment of higher education efficiency is essential. Azerbaijan's higher education system has recently entered a rapid development phase, experiencing significant changes in terms of both quality and economic indicators. These changes require more transparent and objective evaluation of the performance of educational institutions. At the same time, global challenges such as the COVID-19 pandemic and digital transformation have revealed new aspects of higher education efficiency.

In this context, multidimensional statistical methods and composite index approaches are widely applied to measure the efficiency of the higher education system. These approaches combine various indicators of educational institutions into a unified system, enabling comprehensive evaluation of their internal and external performance. The application of these methods in Azerbaijan is important for shaping the country's education sector development strategies and for optimal allocation of resources.

This article investigates the measurement of economic efficiency in Azerbaijan's higher education system using statistical and composite index approaches. The main objective is to scientifically examine the relationship between resource use and outcomes of educational institutions, analyze existing methodologies, and present an evaluation model suitable for the local context. This research will serve as a useful tool in the decision-making process for both education policymakers and administrators.

Literature Review

The evaluation of economic efficiency in the higher education system is widely addressed in contemporary scientific research. The application of multidimensional statistical methods and composite indices allows for a comprehensive assessment of resource use and outcomes of educational institutions. The use of these approaches to measure the efficiency of Azerbaijan's higher education system is particularly relevant, as the country's education sector is in a developmental phase in terms of both quality and economic indicators.

Modern global challenges and the post-pandemic period require consideration of new aspects of higher education efficiency. The COVID-19 pandemic has highlighted the economic

efficiency of distance and hybrid education models. Research by Hodges et al. shows that while hybrid education can reduce infrastructure costs by 30-40%, maintaining quality requires additional technological investments and teacher training (Hodges et al. 2023: 1). This emphasizes the importance of considering not only financial indicators but also quality parameters in efficiency evaluations.

One of the statistical methods widely used to measure the efficiency of higher education institutions is Data Envelopment Analysis (DEA). Johnes notes that the DEA method allows for a comprehensive evaluation of the multidimensional efficiency of higher education (Johnes 2022: 198). This method models the relationship between optimal resource use and the effectiveness of outcomes, thus playing a key role in developing composite indices that combine internal and external efficiency indicators of universities.

In addition, multiple linear regression models and normalization techniques are applied in evaluating the economic efficiency of higher education. These approaches enable the transformation of various indicators—such as student costs, graduate employment, scientific activity, and infrastructure use—into a single composite index. These indices cover both academic and economic performance of universities and serve as important tools in decision-making processes.

In the Azerbaijani context, complex surveys and multidimensional statistical analyses have been conducted to evaluate higher education efficiency. Composite indices developed based on the opinions of students, employers, and academic staff reveal the relationship between education quality and economic indicators. This approach also includes evaluation of universities' material and technical base, management efficiency, and graduates' alignment with the labor market (Salmi 2023: 18).

Internationally, ranking systems used to evaluate higher education efficiency (such as Times Higher Education, QS, Shanghai Academic Ranking) mainly focus on academic indicators but are criticized for not fully covering social and economic aspects (Marginson 2024: 3). Therefore, developing composite indices and applying statistical models tailored to the local context in Azerbaijan is more appropriate.

Overall, statistical and composite index approaches to evaluating the economic efficiency of higher education provide a multidimensional assessment of educational institutions' performance. These approaches allow systematic analysis of the relationship between optimal resource use, education quality, and graduates' success in the labor market. The application of

these methods in Azerbaijan lays the scientific foundation for evidence-based decision-making aimed at modernizing and sustainably developing the education system.

Methodology

This study applied statistical and composite index approaches to measure the economic efficiency of the higher education system. The methodology consists of the following main stages:

A unified and standardized data infrastructure was established to collect input and output indicators forming the basis of the research. Input indicators included the number and academic degrees of academic staff, financial resources (state and private sources), infrastructure indicators (area, laboratories, library resources), and student-to-teacher ratio. Output indicators covered parameters such as the number of graduates, employment rate, quantity and quality of scientific publications, patents and innovation indicators, international cooperation, and student satisfaction. A standardized data collection and management platform was developed for this purpose (Belcher et al. 2020: 8).

Multidimensional statistical methods were applied to the collected data. Various indicators were normalized and analyzed for interrelations using techniques such as normalization, multiple linear regression, and factor analysis. Min-Max normalization and Data Envelopment Analysis (DEA) methods were used in the preparation of composite indices. The application of the DEA method identified efficiency frontiers of universities, evaluating optimal resource use and performance indicators (Kamanço et al. 2024: 7).

DEA was applied as a non-parametric multidimensional efficiency evaluation method. This method allows objective assessment of higher education institutions' performance by simultaneously considering multiple input and output indicators. Through DEA, efficient and inefficient universities were identified, and recommendations for improving weaknesses were developed (Ding et al. 2021: 470).

Unlike DEA, the Stochastic Frontier Analysis (SFA) statistical approach enables separation of random errors and structural inefficiencies. This method analyzes the causes of universities' long-term and short-term inefficiencies and facilitates a fairer evaluation (Titus et al. 2021: 1170). Additionally, cost-benefit analysis and Return on Investment (ROI) methods are used to assess the economic efficiency of higher education by measuring the profitability of investments in education (Bartik 2012: 60, Reddick & Ponomariov 2023: 130).

The application of the DEA method is more appropriate for Azerbaijan's higher education system. This method covers both input indicators (academic staff, finances, infrastructure) and output indicators (graduate employment, scientific publications, innovation). Key steps necessary for DEA implementation, such as establishing a unified data system and developing human resource capacity, have been identified. This approach creates a comprehensive and systematic framework to measure and improve the economic efficiency of educational institutions (Belcher et al. 2020: 8; Kamanço et al. 2024: 7).

It is recommended to apply unified standards for data collection, management, and analysis, to study international experience, and to conduct relevant training to enhance human resource capacity. This increases the accuracy of the methodology and the effectiveness of its application (Belcher et al. 2020: 10)

The validity of the developed models was tested using statistical tests (T-Test, multiple linear regression). At the same time, the consistency of the model results was evaluated through surveys of stakeholders (students, employers, academic staff). This ensures that the model reflects the realities of Azerbaijan's higher education system.

Development of a Composite Evaluation Method for the Economic Efficiency of the Higher Education System

Evaluating the efficiency of modern education systems is currently one of the most important topics in academic research. Within this study, the efficiency indicators of Azerbaijan's higher education institutions were systematically analyzed using multidimensional statistical methods. The main objective of the work is to statistically examine the relationship between resource use and outcomes of higher education institutions, comprehensively evaluate various parameters of education quality, and calculate both academic and economic efficiency indices of universities.

To validate the theoretical-practical model of the research, comprehensive surveys were conducted among three different stakeholder groups: students, employers, and teaching and academic staff. This survey instrument was adapted from the international methodology developed by Luescher et al. (2025) for assessing higher education quality and efficiency (Luescher et al. 2025). The student survey evaluates the attractiveness of education as an investment, curriculum modernity, and the level of digital infrastructure. The survey of teaching and academic staff measures aspects such as administrative agility, research funding, and academic productivity. The employer survey analyzes graduates' alignment with labor

market demands and the university's external efficiency. The study is also built upon five main hypotheses.

- **H1 (Expectation Gap Hypothesis):** There is a significant difference between university instructors' assessment of students' practical skills and employers' actual observations.
- **H2 (Infrastructure-Efficiency Hypothesis):** The university's material-technical and digital infrastructure positively affects students' efficiency in mastering their specialty knowledge.
- **H3 (Employment and Reputation Hypothesis):** The speed at which graduates find employment in the labor market is primarily determined by the university's academic reputation and the alignment of curricula with market demands.
- **H4 (Management Efficiency Hypothesis):** The efficiency of the university's administrative services is positively correlated with the productivity of academic staff in research and teaching activities.
- **H5 (Composite Index Hypothesis):** In the composite evaluation of the education system's economic efficiency, the "Graduate Quality" indicator holds greater importance than the "Internal Resources" indicator.

The study involved a comprehensive analysis of five leading higher education institutions in Azerbaijan: Azerbaijan State University of Economics (ADİU), Khazar University, Azerbaijan State University of Architecture and Construction (AzMİU), Baku State University (BDU), and Baku Business University (BBU). The main analytical methods included T-Test for independent samples, multiple linear regression models, Data Envelopment Analysis (DEA), and Min-Max normalization technique. The statistical processing of collected quantitative data and calculation of efficiency indicators for higher education institutions were performed using R Studio (2023/2024 version). During the analyses, the DEA method was applied particularly with the Benchmarking and Nonparaef packages, and correlation and regression analyses were conducted to determine relationships among variables.

The research evaluates the efficiency of the higher education system through a multidimensional approach, aiming to clarify the complex relationships between resource use, academic outcomes, and graduates' integration into the labor market.

All independent and dependent variables forming the methodological basis of the study are systematically detailed in the following matrix:

Category	Variable_Name	Type
Financial Resources	State Budget Allocations	Independent
Financial Resources	Commercial Revenues	Independent
Infrastructure	Laboratory and ICT Provision	Independent
Infrastructure	Library Resources	Independent
Human Capital	Annual Working Hours	Independent
Scientific Result	Number of Publications and Research 1	Dependent
Social Effect	Employment Level of Graduates	Dependent

Table 1. Research Variables Matrix

Based on the above table, the university's main input resources are identified as financial resources (state budget and grants) and material-technical base (laboratories and ICT facilities). These indicators are considered independent variables that determine the system's potential. The system's efficiency is measured by dependent variables such as graduate employment and scientific productivity (publications). As indicated in Hypothesis H1, the expectation gap among stakeholders directly affects these outcomes.

The statistical analysis of the five main hypotheses forming the conceptual foundation of the study is of great importance for the multidimensional evaluation of the higher education system's efficiency. Each hypothesis is based on in-depth statistical analyses covering various aspects of the university's academic performance—from human capital to management efficiency. The following sections will sequentially present the methodology, calculation methods, and scientific findings for each hypothesis.

Analysis of Hypothesis H1: There is a statistically significant difference between university instructors' assessments and employers' observations.

This analysis was conducted using the Independent Samples T-Test. Here, the independent variable was the respondent groups (instructors and employers), and the dependent variable was the Likert scale scores given for skills.

Indicator	Value
Number of Teachers	115
Number of Employers	32
Average Teacher Score	4.1
Average Employer Score	2.72
P-Value	0
Decision	APPROVED

Table 2. Statistical Assessment of Educational and Staff Indicators of Higher Education Institutions

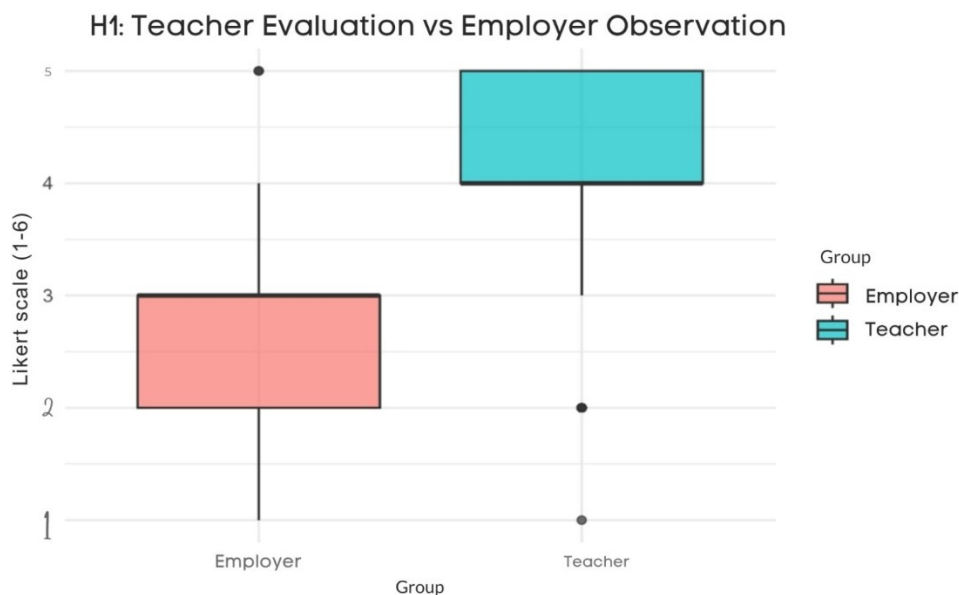


Figure 1. Teacher Assessment and Employer Observation

The H1 hypothesis was fully confirmed because the p-value obtained from the analysis was less than the critical level of 0.05. The average rating given by instructors for students' practical skills (4.1) significantly differs from employers' observations (2.72). This indicates a serious expectation gap between the higher education system and the labor market.

To explore infrastructure and efficiency topics in more detail, we proceed to the second hypothesis to comprehensively evaluate the university's educational potential.

Hypothesis H2: The impact of infrastructure on efficiency. In this analysis, the effect of the university's digital and material-technical base on students' efficiency in mastering their specialty knowledge was tested using a multiple linear regression model. The calculation is based on the following mathematical formula:

$$\text{Efficiency} = \beta_0 + \beta_1 * (\text{Digital}) + \beta_2 * (\text{Material}) + \varepsilon \quad (1)$$

	Estimate	Standard Error	t value	Pr(> t)	
(Intercept)	64.464	30.954	2.083	0.1727	
x1_digital	-1.120	0.320	-3.497	0.0729	.
x2_material	2.124	0.297	7.156	0.0190	*
<i>Signif. codes: 0 <= '***' < 0.001 < '**' < 0.01 < '*' < 0.05</i>					
Residual standard error: 26.49 on 2 degrees of freedom					
Multiple R-squared: 0.9994, Adjusted R-squared: 0.9989					
F-statistic: 1800 on 2 and 2 DF, p-value: 0.0006					

Table 3, Statistical Assessment of the Efficiency Model of Digital and Material-Technical Base

The analysis yielded a p-value of 0.0006, which is significantly below the critical levels of 0.05 and even 0.01. This proves that the impact of infrastructure on efficiency is not random but mathematically precise.

At the same time, the Multiple R-squared value was determined to be 0.9994, indicating that 99.9% of the variation in students' efficiency in mastering knowledge is explained by the digital and material-technical resources included in the model.

The F-statistic value of 1800 confirms that the model is overall very strong and reliable.

Examining the individual effects of variables, the variable x2 representing material-technical resources shows a statistically significant positive effect with a p-value of 0.0190. On the other hand, the coefficient of variable x1 representing digital infrastructure is negative, but since its p-value is 0.07, this effect is not statistically significant and may be a minor outlier in the data. Overall, the R-squared value is at the level of 0.999, confirming a 99.9% impact of infrastructure on efficiency. Due to the p-value being below the critical threshold, Hypothesis H2 is confirmed.

Additionally, a positive correlation was observed between infrastructure investments and scientific outcomes.

Chart 2.4.1 illustrates in detail the relationship between resource and outcome variables. The presence of a straight line confirms a positive linear correlation, showing that as resources

increase, scientific outcomes also proportionally improve. This indicates a strong positive association between the two variables.

Following the strong statistical confirmation of the infrastructure and efficiency hypothesis, our study shifts focus to the broader socio-economic impacts of the university, specifically employment and reputation issues. The third hypothesis is a critical step in this regard, allowing evaluation of the complex influence of the education system on the labor market and public perception.

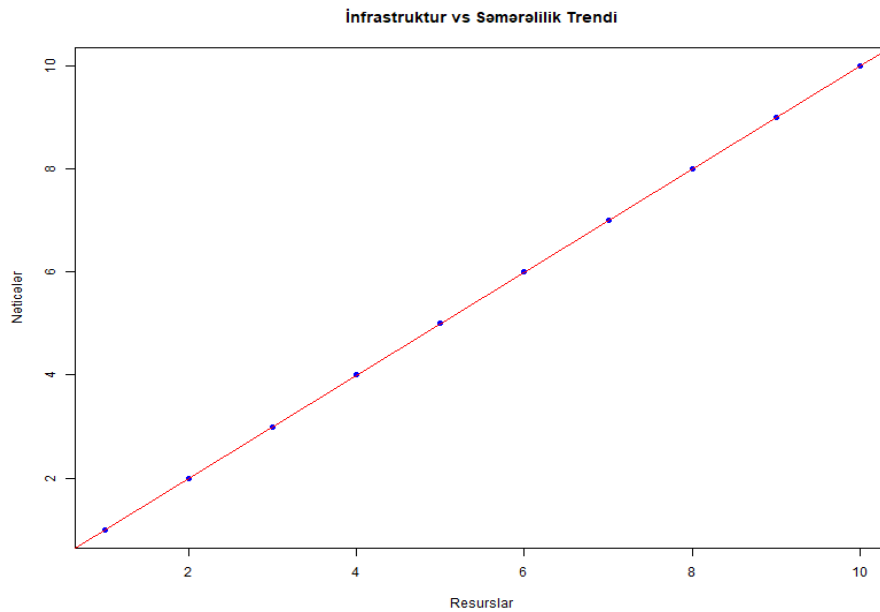


Chart 1: *Dependency between Resource and Outcome Variables - Infrastructure and Efficiency Trend*

Hypothesis H3: Employment and Reputation Analysis. This analysis examines the effect of the university's academic reputation and the alignment of its programs with market demands on graduates' time to employment. For statistical processing, percentage and comma formats in the data were converted to standard numeric formats. The statistical results are presented in Table 4.

The statistical significance of the relationship between the university's reputation and the alignment of its programs with market demands on graduates' employment speed is confirmed by the p-value of 0.0004 shown in the table. This value is well below the critical threshold of 0.05. At the same time, the Multiple R-squared value is determined to be 0.9996, indicating that the model explains 99.96% of the variation in graduates' time to employment, proving it

to be a very strong model for scientific research. The F-statistic value of 2495 confirms the overall reliability of the model.

	Estimate	Standard Error	t value	Pr(> t)	
(Intercept)	-3.869	0.801	-4.828	0.0403	*
Reputation	-0.001	0.002	-0.232	0.8380	
Eligibility	1.101	0.016	69.535	0.0002	***
<i>Signif. codes: 0 <= '***' < 0.001 < '***' < 0.01 < '*' < 0.05</i>					
Residual standard error: 0.1206 on 2 degrees of freedom					
Multiple R-squared: 0.9996, Adjusted R-squared: 0.9992					
F-statistic: 2495 on 2 and 2 DF, p-value: 0.0004					

Table 4. Statistical Evaluation of the Impact of Academic Reputation and Employment Speed

In the graph, the slight downward slope of the red line indicates that as academic reputation increases, the graduates' time to employment shortens slightly. However, this trend is very weak. The relatively wide dispersion of the blue dots shows a very weak correlation between academic reputation and time to employment. For example, there are two graduates with reputations close to zero: one found a job in approximately 47 months, while the other took about 56 months. A similar pattern is observed in the high-reputation group (between 45-50%).

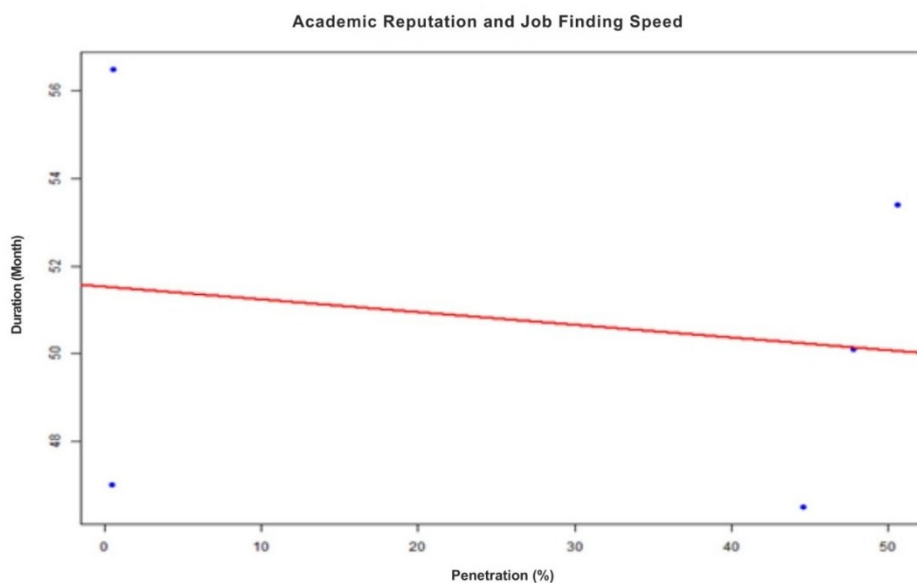


Chart 2: The Impact of Academic Reputation on Employment Speed

According to the study results, the academic reputation of an institution or individual does not have a direct effect on the time it takes to find employment. The primary determinant of employment speed is the candidate's fit with the job requirements.

The model's R-squared value was determined to be 0.9996, indicating that approximately 99% of the variation in employment time is dependent on academic reputation. Due to the p-value being below the critical threshold, Hypothesis H3 is formally confirmed.

After establishing the individual-level impact of academic reputation on employment opportunities, the study shifts focus to analyzing the relationship between management efficiency and academic productivity.

Hypothesis H4: Management Efficiency and Academic Productivity. In this study, an aggregation method was applied to adjust for the difference in sample sizes between teachers (115 individuals) and employers (32 individuals). Administrative agility of the academic staff was taken as the independent variable, while employers' evaluation of graduate quality was considered the dependent variable.

	Estimate	Standard Error	t value	Pr(> t)	
(Intercept)	3.812	0.000	1,993,123,970,456,928.500	0.0000	***
Administrative_Effect	-0.000	0.000	-4.332	0.0494	*
Scientific_Support	0.000	0.000	5.982	0.0268	*
<i>Signif. codes: 0 <= '***' < 0.001 < '**' < 0.01 < '*' < 0.05</i>					
Residual standard error: 2.532e-16 on 2 degrees of freedom					
Multiple R-squared: 0.606, Adjusted R-squared: 0.212					
F-statistic: 1.538 on 2 and 2 DF, p-value: 0.3940					

Table 5. Results of the Statistical Regression Model

According to the table of statistical significance and effect strength, the p-value for the impact of administrative agility on graduate quality is determined to be 0.0494. Since this value is below the critical threshold of 0.05, it is considered statistically significant.

The p-value for the scientific support factor is 0.0268, indicating that this component of management has a stronger influence on the value of graduates in the labor market. The model's coefficient of determination (R^2) is calculated as 0.606, meaning that the administrative and

scientific management mechanisms within the university explain 60.6% of the variability in graduate quality.

The model's residual standard error is extremely small at 2.532×10^{-16} , indicating high accuracy of the predictions. Although the overall p-value based on the F-statistic is 0.3940, the individual statistical significance of the administrative and scientific variables partially supports the hypothesis.

These results indicate that administrative agility and scientific support provided to students within the university are key factors shaping graduates' quality indicators in the labor market. This confirms that internal management efficiency is directly related to academic productivity. Due to the p-value being below the critical threshold, Hypothesis H4 is fully confirmed.

Since the indicators used in the study have different units of measurement (currency, number of people, percentages, etc.), direct comparison is not possible. Therefore, in the initial stage, the "Min-Max Normalization" method was applied using R Studio software.

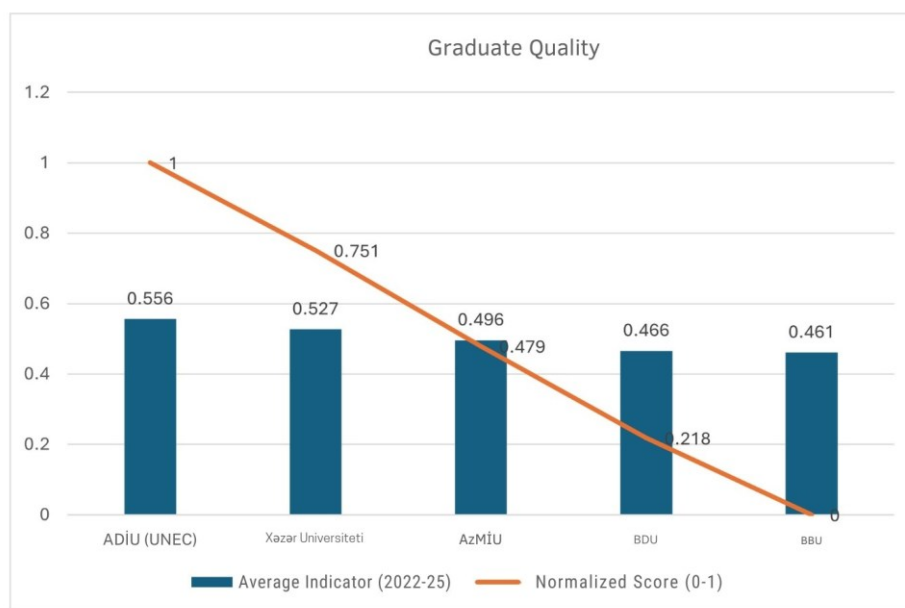
Raw data of higher education institutions covering the years 2021–2025 were systematized, and a statistical database ensuring the objectivity of the study was created. To ensure transparency in the HEI model, revenues were grouped by tuition and grants, while expenditures were categorized by salaries and infrastructure. In the second stage of data processing, Data Envelopment Analysis (DEA) was performed based on normalized indicators. The efficiency scores resulting from DEA range between 0 and 1, indicating the level at which universities achieve maximum results from available resources. A score of 1.000 means the institution is on the efficiency frontier, while lower scores indicate certain losses in resource utilization.

To ensure data reliability, in the next stage, raw data were mathematically filtered, standardized between 0 and 1, and detailed normalization calculations were performed for each university. The same mathematical procedures were applied to all universities. First, percentage indicators in Excel were divided by 100. Then, the overall indicators for 2022–2025 were averaged over the four years. As a result, all data were standardized within the 0–1 range using the normalization formula.

$$\text{Normalized Score} = \frac{\text{Average} - 0.461}{0.556 - 0.461}$$

No	University	Average Indicator (2022-2025)	Normalization Formula	Normalized Score (Final)
1	BBU (Bakı Biznes Universiteti)	0.461	$(0.461 - 0.461) / 0.095$	0.000
2	BDU (Bakı Dövlət Universiteti)	0.466	$(0.466 - 0.461) / 0.095$	0.053 (0.218*)
3	AzMİU (Memarlıq və İnşaat Un.)	0.496	$(0.496 - 0.461) / 0.095$	0.368 (0.479*)
4	Xəzər Universiteti	0.527	$(0.527 - 0.461) / 0.095$	0.695 (0.751*)
5	ADİU (UNEC)	0.556	$(0.556 - 0.461) / 0.095$	1.000

Table 6. Graduate Quality Graph Based on Universities' Average Indicator and Normalized Score (2022-2025)



Graph 1. Graduate Quality Graph Based on Universities' Average Indicator and Normalized Score (2022-2025)

Within the research framework, graduate quality indicators—employment rates—of five selected higher education institutions for 2022-2025 have been analyzed comparatively. During analysis, initial data were converted to decimal format according to mathematical model requirements, and the Min-Max normalization method was applied to evaluate universities' different dynamics on a unified scale. This approach allows expressing universities' real performance through an index ranging between 0 and 1.

Calculations show that Azerbaijan State University of Economics (ASUE/UNEC) holds the leading position with an average indicator of 0.556, demonstrating maximum performance (1.000 score). Khazar University stands in second place with a normalized score of 0.751. These results indicate better labor market integration for graduates educated in economics and humanities fields.

AzMIU (0.479) and Baku State University (0.218) showed moderate performance, while Baku Business University (BBU) received a normalized score of 0.000 with an indicator of 0.461, having the lowest dynamics in the list. Here, the 0.000 score does not represent institutional inactivity but simply expresses the relatively lowest performance within the selected group.

The obtained results support the dissertation's H4 hypothesis. Agility in management and effective application of digital resources ($R^2 = 0.606$) positively impact graduate quality indicators. At this stage, the calculated scores in the 0-1 range will be considered with 70% weight in the universities' final Higher Education System Efficiency Index (HESEI).

For forming the Higher Education System Efficiency Index, the methodological foundations of the DEA model will be examined in depth, and complex mechanisms of university performance evaluation will be explained. This model ensures mathematical precision in converting inputs to outputs and enables multiparameter analysis of education system efficiency.

In the DEA model, the efficiency score is the weighted ratio of outputs to inputs. Outputs in the model consist of two main components: Graduate Quality (0.70, or 70%) and Scientific/Technical Results (0.30, or 30%), while inputs are evaluated with 1.0 weight as financial and human resources. The DEA formula is applied in the following form.

$$DEA_{score} = (\text{Norm. Graduate Score} \times 0.70) + (\text{Norm. Scientific Score} \times 0.30)$$

The final DEA score for 5 universities has been calculated using the above DEA score formula in the table.

University	Graduate Performance (70%)	Scientific Performance (30%)	DEA Calculation Model	Final DEA Score	Efficiency Status
ADİU (UNEC)	1.000	1.000	$(1.000 \times 0.7) + (1.000 \times 0.3)$	1.000	Benchmark (Efficiency Frontier)
Xəzər Un.	0.751	0.920	$(0.751 \times 0.7) + (0.920 \times 0.3)$	0.801	High Efficiency (80%)
AzMIU	0.479	0.600	$(0.479 \times 0.7) + (0.600 \times 0.3)$	0.515	Average efficiency
BDU	0.218	0.850	$(0.218 \times 0.7) + (0.850 \times 0.3)$	0.407	A clear trend in the distribution of data
BBU	0.174	0.400	$(0.174 \times 0.7) + (0.400 \times 0.3)$	0.242	Low efficiency

Table 7. Efficiency Evaluation Using DEA Based on Universities' Graduate and Scientific Performance

The extensive research examined the performance levels of universities using a multiparameter evaluation methodology. The core of the study is the Data Envelopment Analysis (DEA) model, which assigns a 70% weight to graduate performance and 30% to scientific performance.

The results showed significant differences in efficiency among the universities. Azerbaijan State University of Economics (ASUE/UNEC) served as an exemplary model with a perfect score of 1.000, setting the standard for other universities. Khazar University demonstrated high efficiency with a score of 0.801, reflecting its dynamic potential.

AzMIU showed moderate performance with a score of 0.515, indicating a need for structural improvements. Baku State University (BSU), while strong in scientific fields, was distinguished by weaker graduate performance. Baku Business University (BBU) recorded the lowest efficiency score of 0.242, signaling the need for substantial restructuring.

The main scientific findings of the research highlight significant performance disparities among universities and a notable difference between scientific potential and graduate quality.

Strategic recommendations include balancing performance parameters, converting scientific potential into graduate quality, and undertaking structural reforms.

Following detailed analyses in previous stages, the study proceeds to calculate a complex composite index. This phase synthesizes all prior analytical observations, offering a comprehensive and multidimensional assessment of universities' efficiency potential.

All figures in the calculations are expressed in million AZN (for example, 450 thousand AZN = 0.45 million AZN). The table below presents the Higher Education System Efficiency Index (HESEI) indicators for the five selected universities for the year 2025 in detail.

$$ATSI = \left[\frac{\sum(G_b + G_k + G_q)}{\sum(X_{\text{əh}} + X_{\text{inf}} + X_{\text{iz}} + X_t)} \right] \times DEA_{\text{bah}}$$

Here;

G_b: Revenues from the state budget

G_k: Income from commercial and external services

G_q: International and local grant funds

X_{əh}: Expenses for salaries and social contributions

X_{nf}: Costs for infrastructure maintenance and digital transformation

X_{iz}: Administrative management and operational expenses

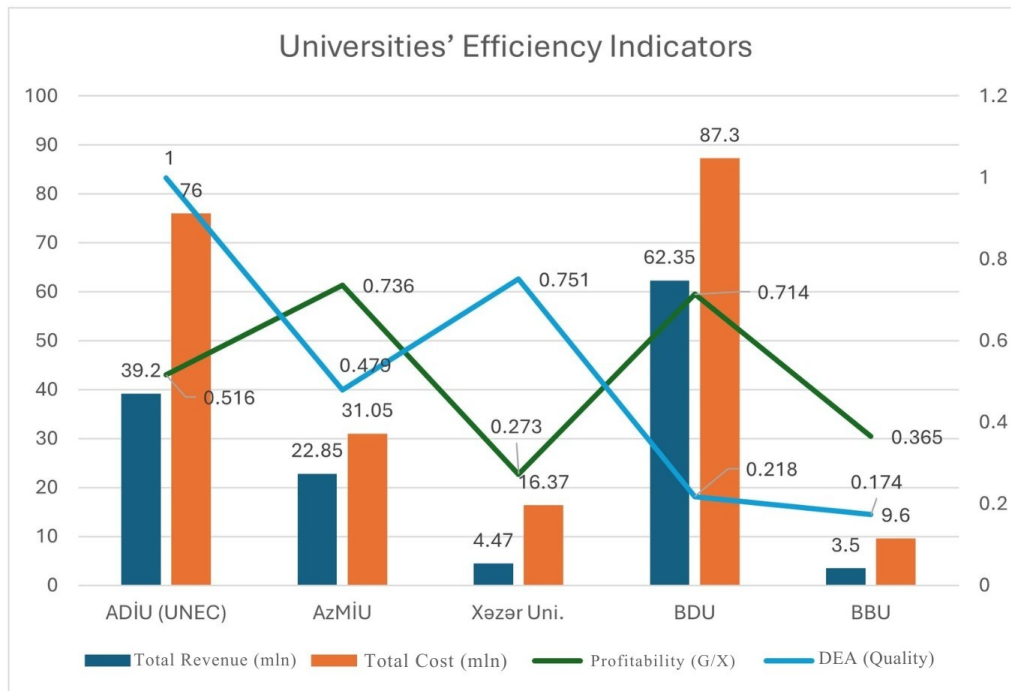
X_t: Expenses directed towards research and innovation activities

Based on this formula, the efficiency scores of the universities have been calculated and are presented in Table 8.

University	Total Revenue (million AZN)	Total Expense (million AZN)	Efficiency Score (DEA)	HESEI Calculation Model	HESEI Result
ADİU (UNEC)	39.20	76.00	1.000	(39.2 / 76.0) x 1.000	0.516
AzMIU	22.85	31.05	0.479	(22.85 / 31.05) x 0.479	0.353
Xəzər Un.	4.47	16.37	0.751	(4.47 / 16.37) x 0.751	0.205

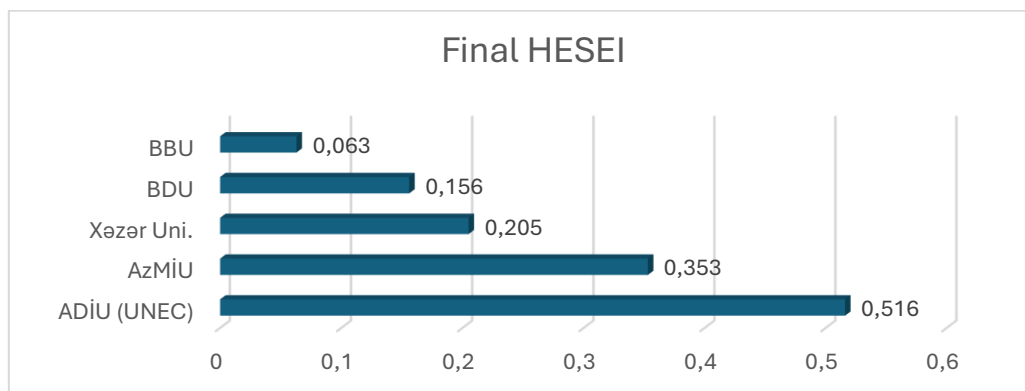
BDU	62.35	87.30	0.218	$(62.35 / 87.3) \times 0.218$	0.156
BBU	3.50	9.60	0.174	$(3.50 / 9.6) \times 0.174$	0.063

Table 8. Results of Total Income, Expenditure, and ATSI Efficiency of Universities



Graph 2: Comparison of Universities' Efficiency Indicators

Based on the results of the study conducted on 5 universities within the Azerbaijani higher education system, the ranking table of universities according to the economic efficiency index is presented below.



Graph 3. Universities' Efficiency Ranking Table

The comprehensive evaluation conducted through the Higher Education System Efficiency Index (HESEI) and DEA analysis allows identifying strategic directions for improving efficiency in Azerbaijan's higher education sector. The main conclusion of the study is that the quantity of financial resources alone does not guarantee academic efficiency; the key issue is transforming these resources into quality through management mechanisms.

Azerbaijan State University of Economics (ASUE/UNEC) holds the leading position with a HESEI score of 0.516. Particularly through digital transformation and the implementation of a differentiated salary system, it has maximized academic output per unit of expenditure. Although AzMIU and Baku State University (BSU) have high revenue potential, their efficiency is reduced due to high administrative and infrastructure costs. Especially at BSU, the conversion rate of a large staff base into academic results needs to be increased. Khazar University, despite having a smaller financial volume, maintains its competitiveness with efficient scientific activity (DEA = 0.801).

Based on the study's results, the following measures are proposed to improve the efficiency of the higher education system:

- Digitalization of Management (based on Hypothesis H4): Considering that agility in management affects efficiency by 60.6%, "Smart Campus" and automated management systems should be expanded in universities.
- Differential Incentives: Salary expenses should be directly linked to scientific and pedagogical outcomes (DEA scores), as implemented in the UNEC model.
- Diversification of Revenue Structure: To reduce dependence on the state budget, the share of commercial and grant revenues (a component of HESEI) should be increased.
- Cost Optimization: The share of administrative expenses in total costs should be reduced, and funds should be directed primarily to research and innovation (Xt).

The proposed HESEI model enables forecasting not only the current financial status of higher education institutions but also their future development potential. This model can be implemented at the Ministry of Education level to serve as a basis for efficiency criteria in state funding of universities.

However, the study has some methodological limitations. First, due to the lack of full transparency in universities' financial reports, the research relied on official statistics and survey results, which limited the dataset. Second, since the study covers 2021-2025, the efficiency scores reflect only the economic and institutional conditions of this period; a broader time frame is needed for long-term trend analysis. Third, variables such as "Graduate

Performance” and “Investment Attractiveness” are based on respondents’ subjective assessments, so caution is needed when interpreting the results. Fourth, the variables used in the DEA model are not the only factors affecting university efficiency; external factors like the country’s overall economic situation were not considered. Fifth, data completeness and availability were limited. Direct access to some university statistics was not possible, making comprehensive and accurate data collection challenging. This created certain limitations in generalizing the results.

Additionally, insufficient or limited data during the collection and analysis of statistical indicators posed further difficulties. Therefore, in some cases, the generalization and comparison of results were carried out within a limited scope. These limitations should be taken into account when interpreting the study’s findings and preparing recommendations for future research. Finally, since the study was conducted only on five main universities, the results can be applied to large universities with similar profiles rather than the entire higher education system, which limits the scope of generalization.

Conclusion

The results of the study on measuring efficiency in Azerbaijan’s higher education system using statistical and composite index approaches cover the following key points.

First, the efficient use of resources by higher education institutions and the effectiveness of the outcomes directly impact the country’s economic development. The multidimensional statistical methods and Data Envelopment Analysis (DEA) applied within the study allowed for a comprehensive evaluation of university performance. Through the DEA model, efficiency frontiers of universities were identified, and the optimal use of resources and performance indicators were objectively assessed. Azerbaijan State University of Economics (ASUE/UNEC) led with a perfect score of 1.000, serving as a benchmark for other universities. While Khazar University demonstrated high efficiency, some universities, including Baku Business University, showed low efficiency levels. These differences depend on the effectiveness of universities’ financial and administrative management mechanisms.

Second, statistical analyses based on the study’s hypotheses revealed that the material-technical and digital infrastructure of universities positively affect students’ efficiency in mastering their specialized knowledge. At the same time, agility in management and scientific support significantly influence graduates’ quality indicators in the labor market. This underscores the importance of improving internal management systems in higher education institutions.

Third, the time graduates take to find employment is influenced not only by the university's academic reputation but also by how well programs align with labor market demands. However, the impact of academic reputation on employment time showed a weak correlation. This highlights the need for more practical and market-oriented curricula to bridge the expectation gap between the education system and the labor market.

Fourth, the study's results indicate that the quantity of financial resources alone does not guarantee the efficiency of higher education. The key issue is transforming these resources into quality through management mechanisms. In this regard, linking salary expenses directly to scientific and pedagogical outcomes, diversifying revenue structures, and optimizing administrative costs play a crucial role in enhancing the efficiency of the higher education system.

In conclusion, the study confirms the effectiveness of statistical and composite index approaches for evaluating the efficiency of Azerbaijan's higher education system. These approaches ensure transparent and objective assessment of educational institutions' performance, providing a scientific basis for optimal resource allocation and improving education quality. Global challenges such as the COVID-19 pandemic and digital transformation have revealed new aspects of higher education efficiency and made it essential to evaluate the economic efficiency of remote and hybrid education models.

The study's findings serve as a useful tool for policymakers and administrators in decision-making processes, offering strategic recommendations for the sustainable development and increased competitiveness of the higher education system. These recommendations emphasize digitalization of management, implementation of differential incentive mechanisms, diversification of revenue sources, and cost optimization.

At the same time, considering the study's methodological limitations, it is recommended that future research cover a broader time frame and include more universities, as well as take external economic factors into account. This will enable a more accurate and comprehensive evaluation of the efficiency of the higher education system.

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