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Evaluating the Network Performance of Islamic Azad University of Guilan Branches Using Data Envelopment Analysis

H. Askary *, A. Amirteimoori, M. Vaez-Ghasemi

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Abstract Nowadays universities in the entire world are the origin of innovative ideas and thoughts. Therefore, many scientific, cultural, social and political developments are stemmed from them. Universities like any other organizations require performance evaluation and measurement in order to use their limited resources optimally and have more efficiency. Since the nature of a university is attracting students and eventually producing science and related graduates, the more additional entries such as the number of students, faculties, educational space and so on a university has, the more outputs such as number of articles, graduates, and so on is expected. In this research, the performance evaluation of Islamic Azad University of Guilan branches which include 15 university branches was conducted in terms of education and research components, and the whole system was studied by using data envelopment analysis techniques. The efficiency of these branches was identified in the year 1393 and at the end of the article, the discussion and conclusions are provided and related suggestions on increasing the productivity of the branches and the possibility of similar follow-up researches was presented.

Keywords: Performance Evaluation, Data Envelopment Analysis, Islamic Azad University of Guilan.

1 Introduction

In the era of knowledge and new technologies and every nation's efforts to find the secrets for pride and durability, undoubtedly universities as the main centers of generating science and learning public knowledge play a decisive role and their development means development in all aspects. Each university has two educational and research sections that together operate to generate science and attract and train students and graduate them and generate income.

Evaluating the performance of parts of a system is always a concern of its senior management. In this era, the dramatic developments in the knowledge of has made a management evaluation system inevitable; so that the lack of evaluation in different aspects of an organization, such as evaluating the use of sources and facilities, personnel, objectives and

* **Corresponding Author. (✉)**
E-mail: Hamid.askary84@gmail.com (H. Askary)

H. Askary
Ph.D. student, Department of Industrial Engineering, Bandar Anzali International Branch, Islamic Azad University, Bandar Anzali, Iran

A. Amirteiymoori
Professor, Department of Mathematics, Rasht Branch, Islamic Azad University, Rasht, Iran

M. Vaez-Ghasemi
Assistant Professor, Department of Mathematics, Rasht Branch, Islamic Azad University, Rasht, Iran

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strategies, is considered as a symptom of organization's sickness. Every organization requires an evaluation system in order to become aware of the desirability and quality of their activities, especially in complex dynamic environments. On the other hand, lacking an evaluation and control system means the lack of communication with the internal and external organization environment and results in aging and eventually death of the organization. It is possible that the top managers in an organization doesn't feel its death because it doesn't happen at once, but studies show that lacking a feedback system make it impossible to find the necessary information for growing, developing and improving an organization's activities and finally it results in organizational death [1].

Every dynamic educational system needs evaluation to face with any changes. Performance evaluation is a necessary performance in every organization [2]. It is a tool to control, monitor and stabilize organization and assures that the organization is taking necessary steps that will lead to achieving its goals. [3] Continuous improvement of organizational performance results in great synergy forces that can support development programs and create excellent business opportunities. Governments, organizations and institutions make advancing efforts in this case.

Without investigating and knowing the progress and achievement of objectives and without identifying the challenges facing the organization and without obtaining feedback and information about the formulated policies and identifying issues that need serious improvement, continuous improvement of performance will not be possible. All of these cases are not possible without measurement and evaluation [4].

Also by considering the creation system, we can see that assessment is at the heart of it. The harmonious order in the universe suggests a complete calculated feedback loop and evaluation system is one of the elements of this loop. Although due to the defects in knowledge and information, people may not to be able to explain it, but the consistency and durability of a system depends on its evaluation and control.

Experts and researchers believe that the performance is the core subject in all the organizational analyses and it is difficult to imagine an organization that is not subject to performance evaluation and measurement. They suggest that paying attention to the performance of organization results in developing the organizational theory and consider performance as the main subject in practical environment. As a result, this discussion has attracted researchers, economists and executives. Therefore, Islamic Azad University of Guilan is no exception either.

University is a system and organization that based on some collective inputs with special processing results in multiple outputs. In the whole system, the aim is to improve the scientific level of the country and the system which by the inputs such as students, faculties and staff can make outputs such as graduates, scientific research and income and like any other system has the ability to evaluate, investigate and improve the quality of performance. Specially, university is reviewed on the two bases of education department and research department. Therefore, we tried to evaluate this organization in the year 1393 using data envelopment analysis and show the efficiency of its branches.

2 Literature review

2.1 Data envelopment analysis

Data envelopment analysis is a technique presented by Charnes- Cooper-Rhodes [5] in 1978 for measuring the efficiency of the decision making units by using a mathematical programming.

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Since 1975, Farell [6] by defining multiple inputs and one output for every unit was able to cover data with a function as the production function and calculate the relative efficiency of all units with this function. In 1978, by extending Farell's work to one input and multiple outputs, Cooper et al. [5] could establish a new technique which can obtain a criterion for the performance with multiple input and output factors. This method was called Data Envelopment Analysis (DEA). It was based on a mathematical programming to measure the efficiency of the decision making units (DMU). This method with its short life is used in all the organizations such as banks, insurance, factories, educational centers, hospitals, highways and so on for their performance evaluation.

It should be noted that in this technique, all the input and output indicators can have any kinds of data; for example, quantitative, qualitative, interval, ordinal, fuzzy or probable. The performance of a system can be measured both absolutely and relatively. Absolute performance of a unit is the result of comparing it with international standards. Relative performance is the result of comparing units with each other and a standard obtained from the current condition of society. Absolute performance is not considered generally for these reasons: international standards are not available or can't be used in this society. Long distance between studied units and the international standards results in hopelessness and despair among managers and its biggest advantage is determining the distance of studied units with the world realities which shows the actual place and real performance of the system. Relative performance of a unit results from comparing performance indicators of this unit with other homogeneous units of the competitive percent.

To calculate the relative efficiency with data envelopment analysis, it should be noted that the chosen system from decision making units should be homogeneous, meaning that all of the units should have homogeneous indicators for evaluation. Choosing a system for evaluation is very difficult, since that choosing comparing indicators should be done with the objective of evaluating them.

Each evaluation view has its own unique indicators and evaluation should be done with them. Therefore, having only similar names for these units (such as bank, insurance, and so on) can't show their homogeneity.

When choosing comparing indicators of units, these should be considered:

1. Indicators should show the whole performance of units. None of these indicators should be ignored in line with the evaluation view.
2. You can't choose different and multiple indicators to obtain different views.
3. The low number of indicators makes the results inaccurate. The high number of indicators confuses the researcher and requires more complex computational procedures that are not recommended in ant scientific works.
4. The value of indicators should be collected very carefully in order to ensure their accuracy.
5. The values of all data should be for a certain time and not collected in different times. This can ensure that all the parameters' dependence on time is equal. Inflation factor should be ignored.
6. Chosen indicators should be measurable. For collecting them we should have a criterion, whether quantitative or qualitative, which is not dependent on individual opinions if possible.

Given the above conditions for choosing indicators, researcher should be aware that choosing a set of homogenous decision making units depends on the aim of evaluation.

Using data envelopment analysis requires that all the chosen indicators should be divided into two categories: input and output, which briefly describe them.

Input is an indicator given to the system as facilities and costs so that system can do a production procedure with it. In a banking system, input can be personnel, equipment, costs

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and so on. It should be noted that each input is generally the total costs, meaning that system has to pay some costs to prepare them. Outputs are indicators resulted from them system after the procedure conducted on inputs. In a banking system, outputs can be absorbed resources, granted facilities, obtained profits, demands made from the facilities, provided services, customer satisfaction and so on. All the above indicators are resulted from the procedure a bank conducts on its facilities, costs, personnel and equipment. In the banking network, you should notice that in the procedure of granting facilities to obtain profit, an output such as demands is resulted. This output is undesirable if its increasing is not desirable and we always try to decrease it.

Generally, the most important feature of inputs is indicators that when increase, if you can't increase any of the outputs, the system's efficiency and performance decreases. In other words, if two homogenous units have equal output values but the first unit in first input is less than the second unit, the second unit comparing to the first unit is not efficient and have a less performance.

Likewise, if two homogenous units have equal output values but the second unit has less desirable outputs than the first input, the second unit comparing to the first unit is not efficient and have a less performance

2.1.1 Parametric methods

From the very old times, parametric method was one of the known methods to estimate the production function. In fact, it can be said that until 1975 when Farell suggested the non-parametric method [6], parametric method was used. In this method, a certain form of a function is considered for estimating the production function and function parameters are determined by using mathematical methods which is known as curve fitting.

$$Q = F\left(x1, x2, \ldots, xm\right) = A.\prod_{i=1}^{m} X_i^{\alpha_i} \quad (1)$$

$x1, x2, \ldots, xm$ are inputs and 'Q' is output of the function which $A, \alpha_1, \alpha_2, .., \alpha_m$ should be estimated.

In order to estimate the parameters, different methods can be used, such as minimizing total absolute deviation, minimizing the sum of squared deviations and minimizing the maximum deviations.

2.1.2 Efficiency definition

Efficiency is a managerial concept that has a long history in management science [7]. It shows that an organization has used its resources very well regarding the production to the best performance in a certain period of time ratio [8].

Every time the decision making unit has one input and one output, its efficiency is defined as the output to input ratio of that same unit. When having multiple inputs and outputs, is the cost of inputs and outputs is determined ($C\text{-}_i$ and $P\text{-}_r$), then the efficiency of 'P' unit is calculated as:

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$$\text{The efficiency of 'O' unit:=} \frac{\sum_{r=1}^{s} P_r y_{rp}}{\sum_{i=1}^{m} C_i x_{ip}} \quad (2)$$

But the cost of inputs and outposts is not always clear; therefore, DEA is used in these cases.

2.1.3 Efficiency

Efficiency is related to performing operations in organization accurately; it is the decisions that are taken with the aim of reducing costs, increasing production volume and improving the quality of product [9].

Efficiency is the ratio of resulted actual yield and the specified standard yield (expected) or the ratio of amount of work performed and the amount of work that should be done.

Efficiency scales are among those scales presented for defining and evaluating the productivity. Efficiency scales compare inputs or resources of an organization with the products and final services. Efficiency refers to the ratio of services and products quantity and financial costs or the workforce necessary for providing them. However, this scale and method of productivity measurement doesn't measure customer satisfaction or access to the desired goal [10].

2.1.4 Absolute efficiency

Assume that for certain decision making units, international standard for an input-output unit is equal to Y*. If decision making unit generate Y_0 output units by consuming one input unit, absolute efficiency will be $y_{0/}$ y*.

2.1.5 Relative efficiency

Assume that decision making units $1,2,\ldots,n$ generate $y_1, ..., y_n$ by consuming $x_1,\ldots,x_n$, respectively. Relative efficiency for 'k' unit shown with RE-k is defined as:

$$RE_K = \frac{\frac{Y_k}{X_k}}{MAX\ \{V_i | X_I : i = 1 \ldots n\}} \quad (3)$$

CCR Model

A: CCR model with input nature: the aim is to reduce the maximum input level with θ ratio so that the minimum of that output can be generated:

$$\begin{aligned} &Min\ \theta \\ &s.t. \\ &\quad (\theta X_0, Y_0) \in T_c \end{aligned} \quad (4)$$

Given the structure, we have:

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$$\sum_{j=1}^{n} \lambda_j X_j \le \theta X_0$$

$$s.t.$$

$$\sum_{j=1}^{n} \lambda_j Y_j \ge Y_0, \tag{5}$$

$$j = 1,...,n, \qquad \lambda_j \ge 0.$$

Which is called covering form of CCR model with input nature and if the optimum amount of the objective function is 'θ^*', $0 < \theta^* \le 1$ is proved.

3 Research methodology

3.1 Statistical population

Statistical population of this research constitutes 15 branches of Islamic Azad University in Guilan, including Astara, Astaneye Ashrafiyeh, Bandar Anzali, Talesh, Rasht, Roudbar, Roodsar and Amlash, Sowme'eh Sara, Fouman and Shaft, Lahijan, Langerud, international center of Bandar Anzali, Siahkal, Lashtenesha and Masal.

3.2 DEA multi-component model

In this section a method is presented to study performance evaluation of Islamic Azad University of Guilan branches with multi-component model. Evaluating the relative efficiency of organization components which have multiple inputs and outputs is done by DEA model and its extension.

When a system with different components becomes efficient in evaluation, it can be said that all of its components work efficiently, but if this system in inefficient, when using standard DEA models, its component efficiency is not considered despite any kind of evaluations, such as cost efficiency, income efficiency, total efficiency.

Professor Cook for the first time published an article about component efficiency in 2001. Professor Beasley also conducted some researches regarding educational and research efficiency in London University which resulted in publishing an article in 2002. Then in 2003, Cook completed his article [11].

In this regard, many applied articles are published including ranking multi-component units by context-dependent DEA [12], Multi-Component Efficiency with Shared Resources in Commercial Bank [13], Ranking of decision making units in data envelopment analysis [14] and DEA-like models for multi-component performance measurement [15], Efficiency evaluation of urban development in Yazd City, Central Iran using data envelopment analysis applied mathematics and computation[16] and Sustainable Product Design Performance Evaluation with Two-Stage Network Data Envelopment Analysis,[17] and A three-stage DEA model to evaluate learning-teaching technical efficiency: Key performance indicators and contextual variables [18].

In figure 1.1 we can find inputs and outputs that should be investigated in the system to determine its efficiency:

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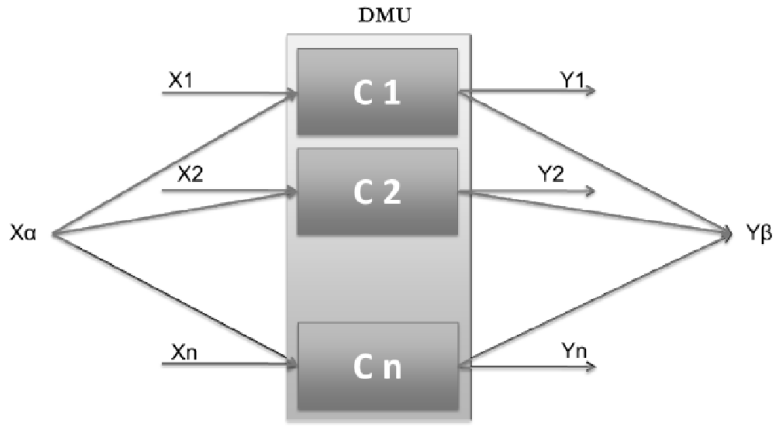


Fig. 1 conceptual model of multi-component data envelopment analysis

If we consider as the efficiency of first component and x and x inputs weight as v and v respectively and y and $\bar{y}$ inputs weight as u and $\bar{u}$, then we have:

$$e_0^1 = \frac{\sum_{r=1}^{s} u_r y_{r1} + \sum_{r=1}^{s} \bar{u}_r \beta^r \bar{y}_r}{\sum_{i=1}^{m} y_i x_{i1} + \sum_{i=1}^{m} \bar{y}_i a^i \bar{x}_i} \tag{6}$$

Also we can this model for next components. In the end, to obtain the final efficiency of the system, we use this model:

$$e_0^a = \frac{\sum_{r=1}^{s} u_r y_{r1} + \sum_{r=1}^{s'} \bar{u}_r \beta^r \bar{y}_r + \sum_{r=1}^{s} u'_r y_{r2} + \sum_{r=1}^{s} \bar{u}_r \left(1-\beta^r\right) \bar{y}_r}{\sum_{i=1}^{m} v_i x_{i1} + \sum_{i=1}^{m'} \bar{v}_i a^i \bar{x}_i + \sum_{i=1}^{m'} v'_i x_{i2} + \sum_{i=1}^{m'} \bar{v}'_i (1-a^i) \bar{x}_i} \tag{7}$$

To use this model, we should convert it to linear model:

$$Max \sum_{i=1}^{b} U^{it} Y_k^i + \sum_{i=1}^{b} \bar{U}^{s_i t} Y_k^c$$

$$s.t. \tag{8}$$

$$\sum_{i=1}^{b} U^{it} X_k^i + \sum_{i=1}^{b} \bar{V}^{s_i t} X_k^c = 1$$

$$\sum_{i=1}^{b} U^{it} Y_j^i + \sum_{i=1}^{b} \bar{u}^{s_i t} Y_j^c - \sum_{i=1}^{b} V^{it} X_j^i - \sum_{i=1}^{b} V^{s_i t} X_j^c \le 1, \quad j = 1,\ldots,n$$

$$U^{it} Y_j^i + \bar{U}^{s_i t} Y_j^c - \bar{V}^{it} X_j^i - \bar{V}^{s_i t} X_j^c \le 0, \; i = 1,\ldots,b, \; j = 1,\ldots,n$$

$$U^i \ge \varepsilon \quad V^I \ge \varepsilon, \; i = 1,\ldots,b$$

$$U^{s_i} \ge \beta_i \varepsilon \quad V^{s_i} \ge \alpha_i \varepsilon, \; j = 1,\ldots,b$$

$$1\alpha = 1, \; 1\beta = 1 \quad ,$$

$$\alpha_i \ge 0 \quad , \beta_i \ge 0, \quad i = 1,\ldots,b$$

In which c index is used for shared data between components.

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4. Component efficiency of university branches

4.1 Question data

In this research, Islamic Azad university of Guilan branches are evaluated and given the below figure, two components of education and research have used which are considered as the main mission of universities. Also other indicators such budget, personnel and staff as input and total income indicators for the whole system, extra-university projects for research component and income fees for educational components are considered.

Output data collects in 1393 for Islamic Azad university of Guilan branches are presented in the below table. It should be noted that all of the income figures are in million Tomans.

Table 1 output data

Number	University branch	Extra-university projects	Total articles	Total income of branch	Total income from the fees	Number of graduates
1	Astara,	0	92	62451716	60966401	600
2	Astaneye Ashrafiyeh	0	50	25800636	24868789	504
3	Bandar Anzali,	0	24	77837699	75780130	2714
4	Talesh	0	5	20011214	19353784	200
5	Rasht	0	330	458917842	443575200	3709
6	Roudbar	0	17	19892231	18989523	5
7	Roodsar and Amlash	0	39	33366776	32957496	494
8	Sowme'eh Sara	0	6	34610096	31430484	230
9	Fouman and Shaft	0	7	6160392	53767238	281
10	Lahijan	1250	376	27882286	257527188	1723
11	Langerud	0	36	41861458	40546786	393
12	International center of Bandar Anzali	0	36	82554835	67550305	69
13	Siahkal	0	2	20549547	19840669	158
14	Lashtenesha	0	23	20549547	19840669	626
15	Masal.	0	0	8263498	7965030	113

Output data collects in 1393 for Islamic Azad university of Guilan branches are presented in the below table. It should be noted that all of the income figures are in million Tomans.

Table 2 input data

Number	University branch	Research budget	Educational budget	Number of staff	Number of faculties
1	Astara,	4939563	2451130	85	96
2	Astaneye Ashrafiyeh	1736777	419915	15	21
3	Bandar Anzali,	5983527	227815	76	83
4	Talesh	1473233	292676	22	16
5	Rasht	27095070	15380778	311	231
6	Roudbar	2046463	838000	24	27
7	Roodsar and Amlash	2700994	2226909	32	34
8	Sowme'eh Sara	1851397	3617619	18	13
9	Fouman and Shaft	4549481	6505432	34	34
10	Lahijan	16676280	10319381	256	253
11	Langerud	3030234	459594	42	34
12	International center of Bandar Anzali	3288686	316857	6	0
13	Siahkal	1247634	391857	7	7
14	Lashtenesha	1927629	251000	7	7
15	Masal.	349579	73006	6	2

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4.2 Results

In the following, the above multi-component model is used for component evaluation of Islamic Azad university of Guilan branches and then the efficiency of research and educational components is presented separated by Guilan branches. As you can see in the below table, in terms of research components, Rasht, Lahijan and International Center of Bandar Anzali were efficient. Also in terms of research components, International Center of Bandar Anzali and Lashtenesha were efficient.

As you can see, small units and educational centers had higher efficiency and this is because of their low inputs. By investigating the Anzali branch, it is apparent that this branch without faculty and only 6 staff could obtain incomes three times more than other branches. This ratio also was very important when comparing its efficiency with other branches such as Lahijan and Rasht.

Table 3 Research & Educational efficiency

	Research efficiency	Educational efficiency
Astara,	74.4%	13.1%
Astaneye Ashrafiyeh	100.0%	28.4%
Bandar Anzali,	42.6%	100.0%
Talesh	54.1%	30.5%
Rasht	100.0%	26.6%
Roudbar	46.2%	6.0%
Roodsar and Amlash	65.8%	19.7%
Sowme'eh Sara	74.5%	24.4%
Fouman and Shaft	7.0%	21.8%
Lahijan	100.0%	13.4%
Langerud	65.7%	37.8%
International center of Bandar Anzali	100.0%	100.0%
Siahkal	65.6%	43.8%
Lashtenesha	87.5%	100.0%
Masal.	94.2%	73.8%

In the following, the efficiency of all the branches in Guilan province is presented. This efficiency is obtained based on multi-component model and shared inputs and outputs and inputs and outputs of the total system.

Table 4 Total efficiency

	Total efficiency
Astara,	0.742154
Astaneye Ashrafiyeh	0.999569
Bandar Anzali,	0.54101
Talesh	0.994493
Rasht	0.461363
Roudbar	0.657255
Roodsar and Amlash	0.744356
Sowme'eh Sara	0.218005
Fouman and Shaft	0.993247
Lahijan	0.657271
Langerud	1
International center of Bandar Anzali	0.656067
Siahkal	0.656067
Lashtenesha	0.999983
Masal.	0.941643

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By considering the rating of branches, the efficiency of comprehensive units such as Rasht and Lahijan is obtained as:

Comprehensive Unit	Research efficiency	Educational efficiency	Total efficiency
Rasht	100.0%	26.6%	0.994493
Lahijan	100.0%	13.4%	0.993247

The efficiency of other branches should be evaluated as the same way in their groups. Focusing on four centers in the province with their efficiency as:

Comprehensive Unit	Research efficiency	Educational efficiency	Total efficiency
International Anzali	100.0%	100.0%	1
Lashtenesha	87.5%	100.0%	0.999983
Masal	94.2%	73.8%	0.941643
Siahkal	65.6%	43.8%	0.656067

It can be concluded that the centers, depending on their smallness and more agility and more focused control and minimum faculty members and budget, had good performance, but Siahkal had higher efficiency and in contrast, Anzali branch without any faculties and incomes from higher fees had 100 percent efficiency.

In the following, by considering the rating of branches, the efficiency of average units is obtained as:

Comprehensive Unit	Research efficiency	Educational efficiency	Total efficiency
Astara	74.4%	13.1%	0.742154
Anzali	42.6%	100.0%	0.999569

5 Conclusion

Given the above results, it seems necessary to investigate the total efficiency of branches based on their component efficiency. Some branches performed very well in one component but did not have a good total efficiency and senior managers are concerned with this issue.

In this evaluation, smaller branches had higher efficiency because of more agility but this study has one limitation which is the minimum amount of input indicators; indicators such as the ratio of faculty to students and so on that bigger comprehensive units should pass minimum of them.

On the other hand, one of the clearest subjects in this study is the educational efficiency of smaller branches and higher efficiency of comprehensive branches. Finally, big or small university branches had higher efficiency, but the performance of average university branches was not acceptable.

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