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EVALUATION OF THE EFFICIENCY OF PUBLIC HIGH SCHOOLS IN İZMİR/TURKEY USING DEAHP APPROACH

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ABSTRACT

This study is carried out to assess the relative efficiency of the Anatolian high schools in İzmir /Turkey and to guide inefficient educational institutions to become efficient. Firstly, efficiency measurement is performed by Data Envelopment Analysis (DEA) model. Instead of assigning equal weights to the input and output variables, the analysis is repeated by assigning weights with the aid of the Analytic Hierarchy Process(AHP) model. 3 input and 3 output variables are determined in the study and 47 Anatolian High Schools are analyzed. In İzmir, this study is important since it is the first study to assess the efficiency of Anatolian high schools with Data Envelopment Analytic Hierarchy Process (DEAHP) integrated model.

Keywords: Education, DEA, AHP, Efficiency

1. INTRODUCTION AND LITERATURE REVIEW

Education is one of the most important elements for improvement and development of a nation. For this reason, it is extremely important to carry out studies related to educational institutions and contribute to increase the quality of institutions.

Given that education institutions have crucial functions for individuals and therefore for the whole nation, it would be utterly crucial to conduct efficiency analyses of institutions and to set targets for ensuring efficient education in those which are not operating efficiently.

DEA is a linear programming model to assess the relative efficiency of units when there are multiple inputs and outputs. The model is often considered to be an ideal solution for its availability in analyses with multiple inputs and outputs and its comparatively flexible structure. In an organization with multiple inputs and outputs where each variable is significant in varying degrees, outputs are categorized and included in the analysis according to their degree of significance by using AHP to attain healthier results.

Anatolian High Schools are a special type of public high schools in Turkey. The duration of education is normally 4 years but in some schools, students are required to do an extra year of prep class. They are particularly designed to educate students to pursue a university degree according to their interests and academic success. This study presents the analyses on the efficiency of Anatolian high schools in İzmir, Turkey and evaluates the study data with DEAHP integrated model. This study bears much importance since it is the first study to evaluate the efficiency of Anatolian high schools in the region.

There are a large number of studies conducted by using either DEA or AHP models. To name a few examples conducted with the integrated model; [1] researchers suggested a two step model for organizations with multiple inputs and outputs in studies conducted with (DEAHP) integrated model: in the first step the data are analyzed with DEA and in the second with AHP; [2] the researchers measured relative efficiency of energy efficiency technologies in the national energy efficiency plan sector by using AHP and DEA integrated models. In practice, CCR model used to be conducted to

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assess outputs while this new approach indicated that AHP and DEA integrated model can be an ideal model for the solution of multi-criteria decision making problems in the energy sector; [3] the researchers conducted a study on the choice of warehouse operator network by combining DEA and AHP models; [4] a study was conducted on the suppliers for BEKO company, which analyzed the data by using AHP model and then the same data by using DEAHP integrated model; [5] the researchers evaluated the risks of different bridge designs by using DEA/AHP integrated model to evaluate criteria (with AHP model) and to determine the values (with DEA model); [6] in a study on the efficiency of notebooks in a wide range of brands and models, the variable returns to scale (BCC) model was used by using EMS package program to analyze 2 different efficiency analyses; this first analysis was conducted with DEA model and the second analysis was conducted after adding weights to DEA model with the help of AHP model; [7] the researchers enlisted the activities of local governments in China using the DEA and AHP integrated model; [8] a study was also conducted to evaluate the efficiency of 26 public hospitals in Ankara with 4 input variables and 5 output variables. The efficiency analysis was performed with DEA model initially, then weights were assigned to input and output variables with the help of AHP model and the efficiency analysis was repeated with DEA model. In the DEA analysis, 13 hospitals were found to be effective whereas 10 hospitals were noted to be efficient in the analysis performed with AHP-weighted DEA model; [9] in a similar study, the researchers conducted a DEAHP analysis with the data obtained from a steel plant in India. The activities of 8 financial years were evaluated by using the CCR model; [10] in another study conducted to evaluate the efficiency of 12 faculties in Serbia, constant returns to scale model was used, which identified 2 input variables and 3 input variables; [11] the export efficiency of 30 textile and pret a porter companies was assessed with DEA model, which included data from 2012 by using 4 input and 1 output variables. AHP model was used to determine the factors of efficiency for those with 100% efficiency; [12] 8 non-life insurance companies in Turkey conducted performance evaluation tests for financial rates by using ratio analysis based on DEA and AHP models; [13] in another study, the researchers performed an analysis by integrating grey relational analysis (GRA) into DEA and AHP models in a multi-hierarchical structure; and [14] in a relevant study, the researchers proposed a integrated model of DEA and AHP to evaluate efficiency in higher education in Greece.

2. BASIC CONCEPTS: PERFORMANCE AND EFFICIENCY

Performance refers to a qualitative and quantitative statement that characterizes to what extent an individual, a group, or an organization can attain their targets [15]. Seven dimensions of performance in an organizational business structure are efficiency, outputs and inputs, performance, quality, innovation, quality of work life, profitability and budget compatibility [16]. Considering the unlimited demand and limited supply of goods and services, it can be reasonably presumed that efficiency and performance would remain at the heart of organizational structures [17]. Productivity is an indicator obtained by the ratio of the production amount to the total input, namely, acquiring the highest output with a certain amount of input or a certain amount of output with the lowest input [18]. The efficiency is a performance dimension that demonstrates how an enterprise makes use of its resources [19]. In other words, it shows the extent to which actual performance should be approximate to the desired performance [20]. The efficiency concept is directly related to inputs, which indicates the optimum use of inputs. As the rate of efficiency gets closer to 1, the inputs are regarded as being used at an optimum level. Thus, efficiency is expressed by the ratio of the actual output to the maximum output obtained [21]. Efficiency types are categorized as technical efficiency, scale efficiency and allocation efficiency.

$$Efficiency = Actual\ output\ /Actual\ capacity$$

3. DEA AND AHP MODELS

3.1. DEA

DEA was first designed by Charnes, Cooper and Rhodes in 1978 [22]. Indeed, it has become one of the most popular models in operations research and management science. The success of analysis lies in its task-oriented approach focusing on the relative efficiency of decision making units (DMU) [23]. DEA is a nonparametric model that measures the relative efficiency of DMUs with multiple inputs and outputs [24]. DEA generates efficiency ratios by proportioning total weighted outputs to total weighted inputs for DMUs.

$$Max \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \quad , \quad j=1, \ldots, n \qquad \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \leq 1 \quad , \quad k=1, \ldots, n$$

$$u_r, v_i \geq 0, \qquad r=1,2,\ldots,s \qquad i=1,2,\ldots,m$$

In this formula, n shows the number of DMUs, x_{ij} shows i. input of j.DMU, y_{rj} shows r. output of j.DMU, u_r shows the weight of the r.output, v_i shows the weight of the i.input, m shows the number of inputs and s shows the number of outputs [25].

The implementation of DEA analysis consists of the following stages: Selection of DMUs, selection of inputs and outputs, data collection and reliability, establishing DEA model and efficiency measurement, efficiency values and efficiency limits, establishing reference groups, target setting for inefficient DMUs and assessment.

DEA models are classified in two groups as input-oriented and output-oriented. The objective in the input-oriented model is to investigate how much input can be reduced to achieve a certain level of output. The main point in the input-oriented model is to determine the optimum input composition to obtain maximum output. The output-oriented model, on the other hand, explores how much output can be achieved with a particular input composition. Having created the model, efficiency is measured with the help of the programs used to devise linear programming models [26].

DEA models are classified differently with reference to a variety of criteria. At first, the CCR model was developed for input-oriented and output-oriented studies based on the constant returns to scale but later on the BCC model was developed for variable returns to scale. However, other models have already been developed to deal with different classifications [27].

3.1.1 CCR (Charnes, Cooper, Rhodes) model

This model was developed by Charnes, Cooper and Rhodes in 1978 and it has remained as the most basic DEA model [22]. The model was derived from Farrell's study on the measurement of efficiency in 1957 [28]. The model assumes that all DMUs operate on an ideal scale [29]. The CCR model is categorized as the input-oriented CCR model and the output oriented CCR model.

The input-oriented CCR model aims to minimize inputs while attaining a specific output level. The output-oriented CCR model seeks to maximize output without requiring more than observed input values [30].

The input-oriented CCR model	**The output-oriented CCR model**
$E_k = Max \frac{\sum_{r=1}^{p} u_r Y_{rk}}{\sum_{i=1}^{m} v_i X_{ik}}$ $\frac{\sum_{r=1}^{p} u_r Y_{rj}}{\sum_{i=1}^{m} v_i X_{ij}} \le 1$ $u_r \ge \varepsilon$ $v_i \ge \varepsilon$ $j = 1,\ldots,n$ $r = 1,\ldots,p$ $i = 1,\ldots,m$	$E_k = Min \frac{\sum_{i=1}^{m} v_i X_{ik}}{\sum_{r=1}^{p} u_r Y_{rk}}$ $\frac{\sum_{i=1}^{m} v_i X_{ij}}{\sum_{r=1}^{p} u_r Y_{rj}} \ge 1$ $u_r \ge \varepsilon$ $v_i \ge \varepsilon$ $j = 1,\ldots,n$ $r = 1,\ldots,p$ $i = 1,\ldots,m$

In this formula, *n* indicates the number of DMUs, *p* number of output, *m* the number of input, u_r the weight assigned to *r*.output by *k*.DMU, v_i the weight assigned to *i.* input by *k*.DMU, Y_{rk} *r.* output generated by *k*.DMU, X_{ik} *i*. input generated by *k*.DMU, Y_{rj} *r*. output generated by *j*.DMU and X_{ij} *i*. input generated by *j*. DMU and ε a sufficiently small positive number [31].

3.1.2. BCC (Banker, Charnes, Cooper) model

This model was developed by Banker, Charnes and Cooper in 1984 with the assumption of variable returns to scale (VRS) and is referred as the BCC model in literature [32]. According to Bowlin in 1987, the density vector λ in the variable returns to scale model is confined with the sum of the decision variables equal to 1 [33], which is the main difference between the BCC model and the CCR model. Consequently, BCC models are used to measure only technical efficiency with the assumption of variable returns to scale. While a DMU must be efficient in both technical aspects and scalewise in a CCR model, it is quite eligible in BCC model if it is only technically efficient. The measurement focus in a CCR model is total efficiency whereas in BCC model it is only technical efficiency [34].

The input oriented BCC model seeks to determine the minimum input level to achieve a certain amount of output [18]. The output-oriented BCC model, on the other hand, delineates a certain amount of input and maximum output level [35].

The input-oriented BCC model	**The output-oriented BCC model**
$E_k = Max \frac{\sum_{r=1}^{p} u_r Y_{rk} - \mu_0}{\sum_{i=1}^{m} v_i X_{ik}}$ $\frac{(\sum_{r=1}^{p} u_r Y_{rj} - \mu_0)}{(\sum_{i=1}^{m} v_i X_{ij})} \le 1$ $u_r \ge \varepsilon$ $v_i \ge \varepsilon$ $j = 1,\ldots,n$ $r = 1,\ldots,p$ $i = 1,\ldots,m$ $\mu_0 : unrestricted$	$E_k = Min \frac{\sum_{i=1}^{m} v_i X_{ik} - \mu_0}{\sum_{r=1}^{p} u_r Y_{rk}}$ $\frac{(\sum_{i=1}^{m} v_i X_{ij} - \mu_0)}{(\sum_{r=1}^{p} u_r Y_{rj})} \ge 1$ $u_r \ge \varepsilon$ $v_i \ge \varepsilon$ $j = 1,\ldots,n$ $r = 1,\ldots,p$ $i = 1,\ldots,m$ $\mu_0 : unrestricted$

In this formula, u_r indicates the weight assigned to the *r*.output by *k*.DMU, v_i the weight assigned to *i*. input by *k*.DMU, Y_{rk} *r*. output generated by *k*.DMU, X_{ik} *i*. input used by *k*.DMU, Y_{rj} *r*. output generated by *j*.DMU, X_{ij} *i*. input generated by *j*.DMU and ε a sufficiently small positive number [26].

3.2. AHP

The AHP model involves hierarchization of decision making problems with multiple criteria, the evaluation of the relative significance of the decision criteria, comparison of the decision alternatives according to each criterion, and establishing priority values and a ranking for each decision alternative. At the top of the decision hierarchy, the main objective is formed with a lower level decision criteria and decision alternatives at the bottom level [5].

The implementation of AHP consists of following 4 stages, which are identifying the problem, binary comparison of the criteria, calculation of the weights and consistency analysis.
To obtain the binary comparison matrices of the criteria, the relative significance scale is formed with numbers indicating the significance of the criteria, which ascertains individual judgments regarding all the criteria [36]. 1-9 scale was developed by Saaty in 1980 to indicate their significance levels [37].

Table 1. AHP scale levels [36]

Significance Level	Definition	Explanation
1	Equally Significant	Two criteria are equally significant.
3	Moderately Significant	Experience and judgment prioritize one criterion over the other.
5	Strongly Significant	Experience and judgment deliberately prioritize one criterion over the other.
7	Very Strongly Significant	One criterion is clearly prioritized over the other.
9	Absolutely Significant	Evidence showing the priority of one criterion over the other is highly reliable.
2, 4, 6, 8	Intermediate Values	These are values intermediating between two sequential judgments when agreement is needed.

If the binary comparison that reflects the personal judgment of the decision-maker based on the scale 1-9 are shown with *A*, then a_{ij} indicates the importance of feature *i* according to the feature *j*.

The binary comparison matrix is obtained as follows when m indicates the number of criteria to be evaluated:

When $A = (a_{ij})_{mxm} = \begin{bmatrix} a_{11} & \cdots & a_{1m} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mm} \end{bmatrix}$, $i,j=1,\dots,m$, $a_{ij} > 0$,
if $a_{ij} = 1/a_{ji}$ and $a_{ii} = 1$, $a_{ij} = a_{ik}a_{kj}$, $i,j,k=1,\dots,m$ equalities are provided, the matrix *A* is fully consistent, otherwise, it is inconsistent [5].

Having defined *A* matrix, its elements need be normalized by dividing the value of each element to the sum of the column. In a normalized matrix, significance values (weight values) are found by calculating the arithmetic mean of each row.

Given that b_j, *j*.indicates the total value of a column, the total value of a column is calculated with the formula below.

$$b_1 = \sum_{i=1}^{m} a_{1i}$$

Then, the elements of *A* matrix is divided to the total value of their column with that formula:

$$c_{ij} = \frac{a_{ij}}{b_i}$$

As a result, matrix *C* with $m \times m$ dimension is found by normalizing binary comparison matrix.

$$C = \begin{bmatrix} c_{11} & \cdots & c_{1m} \\ \vdots & \ddots & \vdots \\ c_{m1} & \cdots & c_{mm} \end{bmatrix}$$

C matrix helps to specify relative percentage significance values (i.e. their weight values) of the criteria.

$$w_i = \frac{\sum_{j=1}^{m} c_{ij}}{m}$$

W column vector refers to the percentage weight of the criteria calculated with the arithmetic mean of the rows in a *C* matrix [36].

$$W = \begin{bmatrix} w_1 \\ w_2 \\ . \\ w_m \end{bmatrix}$$

The validity, and therefore factuality, of the results relies on the consistency of binary comparison matrices. The consistency of results is confirmed with consistancy rates (CR). Consistency analysis also asisists to highlight incorrect judgments and to reduce errors [36]. To measure the consistency of binary matrices, CR is calculated by dividing consistency index (CI) to random index (RI). To measure the former, λ_{max} defines the biggest eigenvalue of A matrix and is calculated with (A-λ_{max} I) $w = 0$ formula. The latter, on the other hand, is identified with the size of binary matrix. RI values from 1 to 10 is shown in Table 2.

$$CI = \frac{\lambda_{max} - m}{m-1} \quad , \quad CR = \frac{CI}{RI}$$

Table 2. RI values[2]

m	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0	0	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49

If CR value is less than 0,10, the comparisons of decision makers are considered to be consistent at satisfactory levels; if not, it is noted to be inconsistent, which indicates that AHP can’t produce significant results [2].

3.3. DEA and AHP Integrated Models

The DEA model assesses the efficiency of DMUs by using quantitative inputs and outputs. However, the inputs and outputs in an analysis may not be equally significant. If this is the case, instead of assigning equal weights to the variables, the priority of these variables must be identified in advance [8]. The DEAHP integrated model, which was first developed by Ramanathan in 2006 [38], allows an analysis of the weights of inputs and outputs [4].

The limitations of DEA are that the efficiency levels should not exceed 100% and the weights must be positive. A third limitation of DEA can be to include an expert opinion in regard to weights, which can be created by using the AHP model. The mathematical representation of the third limitation that includes the expert opinion via binary comparison matrices of AHP is as follows:

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1m} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mm} \end{bmatrix}$$

If binary comparison matrix for output-oriented AHP is *A*, the weight limitations are as follows:

$$\frac{u_1}{u_2} \geq a_{12} \rightarrow u_1 \geq a_{12}u_2 \rightarrow u_1 - a_{12}u_2 \geq 0$$

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$$\frac{u_{m-1}}{u_m} \geq a_{(m-1)m} \rightarrow u_{m-1} \geq a_{(m-1)m}u_m \rightarrow u_{m-1} - a_{(m-1)m}u_m \geq 0$$

$$B = \begin{bmatrix} b_{11} & \cdots & b_{1p} \\ \vdots & \ddots & \vdots \\ b_{p1} & \cdots & b_{pp} \end{bmatrix}$$

If binary comparison matrix for input-oriented AHP is *B*, the weight limitations are as follows:

$$\frac{v_1}{v_2} \geq b_{12} \rightarrow v_1 \geq b_{12}v_2 \rightarrow v_1 - b_{12}v_2 \geq 0$$

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$$\frac{v_{p-1}}{v_p} \geq b_{(p-1)p} \rightarrow v_{p-1} \geq b_{(p-1)p}v_p \rightarrow v_{p-1} - b_{(p-1)p}v_p \geq 0$$

By representing these inequalities in line with linear programming, the problem can be solved by simplex or similar algorithms [6].

4. EVALUATION OF THE EFFICIENCY OF ANATOLIAN HIGH SCHOOLS IN İZMİR WITH DEAHP MODEL

This analysis was conducted to evaluate the efficiency of Anatolian high schools in İzmir by using DEAHP integrated model.

4.1. Purpose and Scope of the Research

A literature review suggested that DEAHP integrated model has been extensively used in a variety of studies on health, education and so on. The review particularly focused on educational studies and no previous study has been reported on the Anatolian high education institutions in İzmir, Turkey. The primary purpose of this study is to determine the efficiency of certain Anatolian high schools in İzmir and to make suggestions to improve the efficiency of inefficient schools. DEAHP integrated model was used as the study model with a view to ascertain that the expert opinions are included in the analysis while determining the efficiency of the schools to achieve healthier results. Two different models were carried out to analyze the data. Initially, the efficiency evaluation was conducted with DEA. Afterwards, by adding weight values of the input and output variables, the analysis was repeated.

The study mainly consists of the following steps:
1- Selection of DMUs
2- Establishing input and output variables in DMUs,
3- To carry out the analysis with DEA model to identify the effective and ineffective DMUs,
4- Assigning weights to the input and output variables of DMUs in accordance with the expert opinions obtained with the help of AHP model,
5- Implementation of efficiency analysis by using DEAHP integrated model and retesting efficiency and inefficiency of DMUs.
6- Comparison and discussion of the results obtained with DEA and DEAHP models

4.2. Selection of DMUs

To assure homogeneity, 47 Anatolian High Schools were selected as DMUs in central districts of İzmir province (Balçova, Buca, Gaziemir, Çiğli, Bornova, Konak, Karşıyaka) on the condition that they had the same inputs and outputs. Imam-Hatip High Schools and Vocational and Technical High Schools were excluded in the study for differences in their education programs. These 47 high schools selected for the study are given in Table 3.

Table 3. DMUs for the study

Number	School	Number	School
1	Balçova anatolian high school	25	Necip Fazıl Kısakürek anatolian high school
2	Nevvar Salih İşgören anatolian high school	26	Gaziemir Nevvar Salih İşgören anatolian high school
3	Salih Dede anatolian high school	27	Gaziemir anatolian high school
4	Bornova anatolian high school	28	Kipa 10.Yıl anatolian high school
5	Bornova Cem Bakioğlu anatolian high school	29	Karşıyaka Atakent anatolian high school
6	Bornova Hatice Güzelcan anatolian high school	30	Karşıyaka Behçet Uz anatolian high school
7	Bornova Suphi Koyuncuoğlu anatolian high school	31	Karşıyaka Cihat Kora anatolian high school
8	Çimentaş anatolian high school	32	Şemikler anatolian high school
9	Gülsefa Kapancıoğlu anatolian high school	33	Vali Erol Çakır anatolian high school
10	Hayrettin Duran anatolian high school	34	Karşıyaka anatolian high school
11	Yunus Emre anatolian high school	35	Emlakbank Süleyman Demirel anatolian high school
12	Sıdıka Rodop anatolian high school	36	Gazi anatolian high school
13	Betontaş anatolian high school	37	Karşıyaka high school
14	Buca 85.Yıl anatolian high school	38	50.Yıl anatolian high school
15	Fatih Sultan Mehmet anatolian high school	39	İzmir Kız high school
16	İzmir Buca Aybers Hikmet Karabacak anatolian high school	40	Karataş anatolian high school
17	Buca Fatma Saygın anatolian high school	41	Konak anatolian high school
18	Şirinyer anatolian high school	42	Konak Hürriyet anatolian high school
19	Gürçeşme anatolian high school	43	Namık Kemal high school
20	Buca anatolian high school	44	Selma Yiğitalp anatolian high school
21	Büyükçiğli anatolian high school	45	Vali Vecdi Gönül anatolian high school
22	Çiğli Teğmen Ali Rıza Akıncı anatolian high school	46	Konak Kenan Evren anatolian high school
23	Tuğba Özbek anatolian high school	47	Atatürk High School
24	Çiğli Yıldız Tınas İzmirlioğlu anatolian high school		

4.3. Establishing input and output variables in DMUs

Establishing input and output variables is of utmost important and the variables that best express the process should be selected in order to measure the efficiency with DEA model. A large number of input and output variables decreases the discriminatory power of DEA [39]. The input and output variables used in the field of education are taken as a reference and also they are determined by considering expert opinions. Therefore, the review included studies on education with DEA and the most significant input and output variables in measuring the efficiency of Anatolian high schools that fully represent the process are available in Table 4.

Table 4. Input and output variables

Input variables	**Output variables**
Number of teachers	Number of graduate students
Number of students	Number of students pursuing a university degree
Number of classrooms	YGS+LYS Success Rate

Number of teachers: The total number of teachers working in the selected schools in the 2015-2016 academic year.

Number of students: The number of students attending the selected schools in the 2015-2016 academic year. Besides, it also indicates the school preference of parents as well as the school's capacity to teach students, which, therefore, is also considered as an input criterion.
Number of classrooms: The total physical area. It is the total number of classrooms available in the selected schools in the 2015-2016 academic year.

Number of graduate students: The total number of students who graduated from the selected schools at the end of the 2015-2016 academic year.

Number of students pursuing a university degree: The number of students enrolled in undergraduate, associate and open education courses at selected schools at the end of the 2015-2016 academic year.
YGS + LYS success rate: The ratio of the number of students enrolled in a higher education institution (undergraduate + associate + open education) to the number of students entering the university exam in the same year.

The researchers obtained the information regarding the number of teachers, the number of students, the number of classrooms and the number of graduates through interviews with and officially written petitions to the Ministry of National Education - Strategy Development Services.The number of students enrolled in a university was derived from the Periodicals Section under the title of Research, Publication and Statistics on the Measurement, Selection and Placement Center website, http://www.osym.gov.tr [40]. The success rate of YGS + LYS was obtained from the ratio of the number of students attending a university to the number of students who had taken the university exam.

4.4. Efficiency Analysis with DEA

The input-oriented DEA aims to investigate how the best input composition can be designed. The particular aim of this study was to determine how much input should be decreased/increased to improve the efficiency of inefficient schools, thus it was considered most convenient to use an input-oriented DEA model under the assumptions regarding constant returns to scale. EMS 1.3.0 (Efficiency Measurement System) software was used for the efficiency analysis. The results of the efficiency analysis with 47 DMU, and 3 input and 3 output variables are shown in Table 5. The schools in this table are given as DMU1, DMU2, DMU3, …….., DMU47.

Table 5. Efficiency scores and reference groups of high schools (with DEA model)

Anatolian High Schools	**Efficiency scores**	**Referance Groups**
DMU1	58,53%	3 (0,11) 17 (0,83) 40 (0,00)
DMU2	80,04%	3 (0,27) 17 (0,74)
DMU3	100,00%	8
DMU4	100,00%	6
DMU5	60,76%	4 (0,10) 21 (0,56) 40 (0,24)
DMU6	66,72%	17 (0,51) 21 (0,19) 40 (0,20)
DMU7	58,56%	17 (0,17) 21 (0,52) 40 (0,22)
DMU8	90,05%	21 (0,58) 40 (0,38) 47 (0,07)
DMU9	87,47%	3 (0,05) 17 (0,70) 40 (0,02)
DMU10	91,54%	40 (1,09)
DMU11	83,24%	4 (0,10) 21 (0,96)
DMU12	87,21%	21 (0,78) 40 (0,29)
DMU13	54,86%	17 (0,62) 21 (0,18) 40 (0,09)
DMU14	64,97%	17 (0,80) 40 (0,15)
DMU15	51,57%	4 (0,06) 21 (0,42) 40 (0,38)
DMU16	67,98%	17 (0,20) 40 (0,46)
DMU17	100,00%	27
DMU18	65,05%	21 (0,67) 40 (0,30)
DMU19	58,07%	17 (0,48) 40 (0,28)
DMU20	64,82%	17 (0,28) 21 (0,49) 40 (0,16)
DMU21	100,00%	22
DMU22	74,86%	4 (0,02) 21 (0,91) 40 (0,06)
DMU23	77,15%	21 (0,68) 40 (0,33)
DMU24	72,85%	3 (0,13) 17 (0,60) 40 (0,05)
DMU25	70,21%	17 (0,64) 40 (0,00)
DMU26	71,29%	3 (0,20) 17 (0,54) 40 (0,05)
DMU27	95,73%	17 (0,08) 40 (0,70)
DMU28	70,93%	4 (0,04) 21 (0,50) 40 (0,34) 47 (0,00)
DMU29	66,95%	17 (0,62) 21 (0,32) 40 (0,04)
DMU30	81,64%	3 (0,00) 17 (0,84) 40 (0,05)
DMU31	59,46%	17 (1,08) 40 (0,01)
DMU32	90,49%	3 (0,09) 40 (1,04)
DMU33	47,02%	17 (0,69) 40 (0,10)
DMU34	73,63%	17 (0,11) 21 (0,90)
DMU35	53,88%	17 (0,47) 21 (0,49) 40 (0,03)
DMU36	64,70%	21 (0,79) 40 (0,13)
DMU37	58,22%	4 (0,05) 21 (0,84) 40 (0,09)
DMU38	61,86%	17 (0,33) 21 (0,29) 40 (0,23)
DMU39	81,85%	21 (0,41) 40 (0,31) 47 (0,30)
DMU40	100,00%	38
DMU41	63,91%	17 (0,27) 21 (0,49) 40 (0,15)
DMU42	55,83%	3 (0,02) 17 (0,38) 40 (0,22)
DMU43	36,20%	17 (0,37) 40 (0,28)
DMU44	54,65%	17 (0,50) 21 (0,27) 40 (0,14)
DMU45	81,42%	17 (0,81) 40 (0,04)
DMU46	76,52%	17 (0,85) 40 (0,02)
DMU47	100,00%	3

The analysis of Table 5 indicates that the efficiency scores column gives the percentage of efficiency in Anatolian High Schools. Schools with 100% efficiency are identified as efficient schools and the rest as inefficient. Accordingly, 6 schools were found efficient, which are DMU3 (Salih Dede Anatolian High School), DMU4 (Bornova Anatolian High School), DMU17 (Buca Fatma Saygin Anatolian High School), DMU21 (Buyukcigli Anatolian High School), DMU40 (Karatas Anatolian High School) and DMU47 (Ataturk High School), and 41 schools were inefficient within the scope of this study among which DMU27 (Gaziemir anatolian high school) had the highest efficiency scores and DMU43 (Namık Kemal High School) had the lowest.

An analysis of the reference groups column suggested that DMU3 was taken as a reference point by inefficient schools for 8 times, DMU4 for 6 times, DMU17 for 27 times, DMU21 for 22 times, DMU40 for 38 times, and DMU 47 for 3 times, which shows that DMU40 was the most referred school in the list. The reference group column for inefficient schools also emphasized that to increase its efficiency, DMU27 referred to DMU17 with 8% and DMU40 with 70%. An example to show how to measure target values by using percentages in the reference group column is given below.

$$DMU27_i=(0,08)DMU17_i+(0,70)DMU40_i$$

$DMU27_i$: the target value of DMU27 for *i*. input.
$DMU17_i$: the current value of DMU17 for *i*. input.
$DMU40_i$:the current value of DMU40 for *i*. input.
0,08: the weight of DMU17
0,70: the weight of DMU40
Given the formula above, "the number of students" which is the 2. input is measured as follows:

$$DMU27_2=(0,08)(350)+(0,70)(712)=526,4$$

The current number of students of DMU27 was 630 and the target value for the number of students was noted to be 526. Consequently, it was suggested that the number of students should be reduced to 526 to increase the efficiency in this unit. Similarly, the number of teachers and classrooms of DMU27 were analyzed and it was stated that the unit had an efficiency level of 100% after establishing the target value and analyzing values by using a special program. The same procedure may as well be followed to find target values and improvement rates for other inefficient DMUs.

4.5. Efficiency Analysis with DEAHP Model

DEA is particularly available for evaluating the efficiency of DMUs with quantitative inputs and outputs. Each input and output are assumed to have equal significance. However, input and output values may not always bear significance at the same level. While some inputs or outputs may seem more elemental for the analysis, some may not. As a result, specifying the weights of input and output variables proves to be crucial in terms of providing healthy results. In this study, the input and output weights were identified by using an AHP model. These priority values were included in the analysis and the efficiency was measured again.

To identify the input and output weights, the researchers interviewed with 8 school counsellors from different high schools in İzmir and consequently binary comparison matrices were generated for inputs and outputs. It was reported that comparisons of four binaries were consistent and the weights of these matrices and input and output variables were identified. In the tables below (Table 6-13) the binary comparison matrices and consistency ratios are given.

Table 6. The binary comparison matrice of 1st school counsellor for inputs

Criteria	**The number of teachers**	**The number of students**	**The number of classrooms**
The number of teachers	1	4	3
The number of students	1/4	1	1/2
The number of classrooms	1/3	2	1
CR=0,016			

Table 7. The binary comparison matrice of 1st school counsellor for outputs

Criteria	**The number of graduate students**	**The number of students pursuing a university degree**	**YGS+LYS success rate**
The number of graduate students	1	1/8	1/9
The number of students pursuing a university degree	8	1	1/3
YGS+LYS success rate	9	3	1
CR=0,094			

Table 8. The binary comparison matrice of 2nd school counsellor for inputs

Criteria	The number of teachers	The number of students	The number of classrooms
The number of teachers	1	3	2
The number of students	1/3	1	1/3
The number of classrooms	1/2	3	1
CR=0,046			

Table 9. The binary comparison matrice of 2nd school counsellor for outputs

Criteria	The number of graduate students	The number of students pursuing a university degree	YGS+LYS success rate
The number of graduate students	1	1/7	1/8
The number of students pursuing a university degree	7	1	1/3
YGS+LYS success rate	8	3	1
CR=0,091			

Table 10. The binary comparison matrice of 3rd school counsellor for inputs

Criteria	The number of teachers	The number of students	The number of classrooms
The number of teachers	1	5	7
The number of students	1/5	1	3
The number of classrooms	1/7	1/3	1
CR=0,057			

Table 11. The binary comparison matrice of 3rd school counsellor for outputs

Criteria	The number of graduate students	The number of students pursuing a university degree	YGS+LYS success rate
The number of graduate students	1	1/6	1/9
The number of students pursuing a university degree	6	1	1/4
YGS+LYS success rate	9	4	1
CR=0,095			

Table 12. The binary comparison matrice of 4th school counsellor for inputs

Criteria	The number of teachers	The number of students	The number of classrooms
The number of teachers	1	5	4
The number of students	1/5	1	1/3
The number of classrooms	1/4	3	1
CR=0,075			

Table 13. The binary comparison matrice of 4th school counsellor for outputs

Criteria	The number of graduate students	The number of students pursuing a university degree	YGS+LYS success rate
The number of graduate students	1	1/7	1/9
The number of students pursuing a university degree	7	1	1/3
YGS+LYS success rate	9	3	1
CR=0,070			

As consistency rates are CR< 0,1, it can be therefore deduced that binary comparison matrices are consistent in tables above. The percentages of significance for input and output variables calculated by using matrices are given in Table 14 and Table 15, respectively.

Table 14. Percentages of significance for input variables

Inputs	**1st school counsellor (1st decision maker)**	**2nd school counsellor (2nd decision maker)**	**3rd school counsellor (3rd decision maker)**	**4th school counsellor (4th decision maker)**	**Average Weigth**
The number of teachers	0,623	0,525	0,724	0,665	0,634
The number of students	0,137	0,141	0,193	0,104	0,144
The number of classrooms	0,240	0,334	0,083	0,231	0,222
Total	1,000	1,000	1,000	1,000	1,000

Table 15. Percentages of significance for output variables

Outputs	**1st school counsellor (1st decision maker)**	**2nd school counsellor (2nd decision maker)**	**3rd school counsellor (3rd decision maker)**	**4th school counsellor (4th decision maker)**	**Average Weigth**
The number of graduate students	0,054	0,061	0,059	0,057	0,058
The number of students pursuing a university degree	0,306	0,302	0,251	0,295	0,288
YGS+LYS success rate	0,640	0,637	0,690	0,648	0,654
Total	1,000	1,000	1,000	1,000	1,000

The analysis of the charts indicates that the number of teachers input variable had the highest significance value with 63,4% and that YGS + LYS success rate output variable had the highest significance value with 65,4%.

The top three input variables were the number of teachers, the number of classrooms and the number of students while the top three output variables were YGS+LYS success rate, the number of students pursuing a university degree and the number of graduate students, respectively.

Inputs	i_1	i_2	i_3
i_1	1	4,16	3,6
i_2	0,24	1	0,64
i_3	0,28	1,56	1

Outputs	o_1	o_2	o_3
o_1	1	0,144	0,114
o_2	6,96	1	0,31
o_3	8,74	3,22	1

The input (i) and output (o) variable matrices were analyzed and 6 limitations were added to DEA models.

$\frac{i_1}{i_2} \geq 4,16 \quad i_1 - 4,16\, i_2 \geq 0 \quad ; \quad \frac{i_1}{i_3} \geq 3,6 \quad i_1 - 3,6\, i_3 \geq 0$

$\frac{i_2}{i_3} \geq 0,64 \quad i_2 - 0,64\, i_3 \geq 0 \quad ; \quad \frac{o_1}{o_2} \geq 0,144 \quad o_1 - 0,144 o_2 \geq 0$

$\frac{o_1}{o_3} \geq 0,114 \quad o_1 - 0,114 o_3 \geq 0 \quad ; \quad \frac{o_2}{o_3} \geq 0,31 \quad o_2 - 0,31 o_3 \geq 0$

With the addition of these 6 limitations to the model, the weights were included in the analysis and the efficiency measurement for 47 high schools was repeated with EMS 1.3.0 program. The efficiency scores of the weights included in the analysis and the reference groups of the DMUs are given in Table 16.

Table 16. Efficiency scores and reference groups (with DEAHP model)

Anatolian High Schools	Efficiency scores	Reference groups
DMU1	41,12%	3 (0,11) 4 (0,14)
DMU2	53,73%	3 (0,42) 4 (0,08)
DMU3	100,00%	28
DMU4	100,00%	37
DMU5	55,28%	4 (0,25) 40 (0,24)
DMU6	53,31%	4 (0,16) 40 (0,16)
DMU7	51,16%	3 (0,06) 4 (0,18) 40 (0,17)
DMU8	78,22%	3 (0,05) 4 (0,35) 40 (0,08)
DMU9	50,61%	3 (0,03) 4 (0,05) 40 (0,10)
DMU10	91,54%	40 (1,09)
DMU11	73,74%	3 (0,12) 4 (0,33)
DMU12	69,88%	3 (0,12) 4 (0,31)
DMU13	40,43%	4 (0,18) 40 (0,04)
DMU14	37,28%	40 (0,30)
DMU15	47,98%	4 (0,17) 40 (0,38)
DMU16	60,81%	40 (0,49)
DMU17	66,55%	3 (0,04) 4 (0,15)
DMU18	51,81%	3 (0,03) 4 (0,25) 40 (0,13)
DMU19	44,34%	3 (0,00) 4 (0,06) 40 (0,30)
DMU20	53,93%	3 (0,03) 4 (0,19) 40 (0,12)
DMU21	87,35%	3 (0,14) 4 (0,23)
DMU22	62,22%	4 (0,27) 40 (0,05)
DMU23	63,91%	4 (0,28) 40 (0,13)
DMU24	49,82%	3 (0,10) 4 (0,06) 40 (0,10)
DMU25	27,63%	3 (0,05) 4 (0,00) 40 (0,11)
DMU26	48,80%	3 (0,13) 4 (0,03) 40 (0,16)
DMU27	86,49%	40 (0,72)
DMU28	66,88%	3 (0,09) 4 (0,19) 40 (0,28)
DMU29	48,35%	4 (0,21)
DMU30	51,87%	3 (0,03) 4 (0,12) 40 (0,05)
DMU31	38,64%	3 (0,02) 4 (0,17)
DMU32	88,70%	3 (0,23) 40 (0,96)
DMU33	27,96%	3 (0,04) 4 (0,07) 40 (0,12)
DMU34	58,03%	4 (0,26)
DMU35	41,10%	3 (0,03) 4 (0,22)
DMU36	54,65%	3 (0,26) 4 (0,20)
DMU37	49,55%	4 (0,28) 40 (0,07)
DMU38	51,54%	4 (0,15) 40 (0,20)
DMU39	73,89%	3 (0,11) 4 (0,48) 40 (0,08)
DMU40	100,00%	32
DMU41	52,00%	4 (0,19) 40 (0,12)
DMU42	40,16%	3 (0,00) 40 (0,29)
DMU43	27,59%	40 (0,34)
DMU44	42,65%	3 (0,00) 4 (0,18) 40 (0,10)
DMU45	45,92%	3 (0,02) 4 (0,09) 40 (0,07)
DMU46	41,81%	3 (0,06) 4 (0,09) 40 (0,03)
DMU47	89,25%	3 (0,06) 4 (0,94)

It was suggested that there was a slight decline in the number of efficient schools in Table 16 after adding the weight limitations to DEA model by using AHP. It was further noted that in this table, there were only 3 schools with 100% efficiency score. The target values for input variables of inefficient DMUs on the basis of reference groups in Table 16 are given in Table 17.

Table 17. Target values for inefficient DMUs after DEAHP

	target values		
Anatolian High	**the number of**	**the number of**	**the number of**
DMU1	18,42	230,04	9,88
DMU2	26,24	227,88	11,36
DMU3	100% efficient.		
DMU4	100% efficient.		
DMU5	36,97	528,63	20,02
DMU6	24	342,88	12,96
DMU7	29,11	394,82	15,31
DMU8	40,39	571,31	22,94
DMU9	11,47	150,85	5,68
DMU10	57,77	776,08	25,07
DMU11	37,29	504,63	21,06
DMU12	35,35	476,01	19,9
DMU13	19,58	286,06	11,36
DMU14	15,9	213,6	6,9
DMU15	36,63	513,83	18,6
DMU16	25,97	348,88	11,27
DMU17	16,31	225,45	9,34
DMU18	32,46	458,41	17,97
DMU19	21,72	299,46	10,38
DMU20	26,11	365,43	14,26
DMU21	28,47	366,93	15,58
DMU22	28,84	421,97	16,81
DMU23	34,05	493,24	19,23
DMU24	15,52	184,06	7,38
DMU25	8,03	91,82	3,33
DMU26	17,11	191,95	7,5
DMU27	38,16	512,64	16,56
DMU28	37,23	495,55	18,9
DMU29	20,37	300,51	12,18
DMU30	15,61	215,42	8,59
DMU31	17,37	248,67	10,18
DMU32	61	745,62	25,76
DMU33	14,91	196,41	7,46
DMU34	25,22	372,06	15,08
DMU35	22,66	322,92	13,24
DMU36	30,84	356,4	15,76
DMU37	30,87	450,52	17,85
DMU38	25,15	357,05	13,3
DMU39	55,64	773,54	31,44
DMU40	100% efficient.		
DMU41	24,79	357,33	13,78
DMU42	15,37	206,48	6,67
DMU43	18,02	242,08	7,82
DMU44	22,76	328,78	12,74
DMU45	13,32	184,03	7,15
DMU46	12,96	166,35	6,87
DMU47	93,82	1361,34	55,48

Inefficient institutions will reach 100% efficiency when they adjust their input values in accordance with Table 17.

Tablo 18. Efficient Schools according to DEA and DEAHP analyses

Efficient Schools according to DEA	**Efficient Schools according to DEAHP analyses**
Salih Dede anatolian high school (DMU3)	Salih Dede anatolian high school (DMU3)
Bornova anatolian high school (DMU4)	Bornova anatolian high school (DMU4)
Buca Fatma Saygın anatolian high school (DMU17)	Karataş anatolian high school (DMU40)
Büyükçiğli anatolian high school (DMU21)	
Karataş anatolian high school (DMU40)	
Atatürk High School (DMU 47)	

As seen in Table 18, the number of efficient schools was 6 in DEA while it decreased to 3 after including expert opinions in the analysis, and efficiency scores of Buca Fatma Saygın Anatolian High School, Büyükçiğli Anatolian High School and Atatürk High School were reported to be less than 100%.

Tablo 19. A comparison of efficiency scores with DEA and DEAHP models.

Anatolian High Schools	Efficiency scores with DEA	Efficiency scores with DEAHP integrated model
DMU1	58,53%	41,12%
DMU2	80,04%	53,73%
DMU3	100,00%	100,00%
DMU4	100,00%	100,00%
DMU5	60,76%	55,28%
DMU6	66,72%	53,31%
DMU7	58,56%	51,16%
DMU8	90,05%	78,22%
DMU9	87,47%	50,61%
DMU10	91,54%	91,54%
DMU11	83,24%	73,74%
DMU12	87,21%	69,88%
DMU13	54,86%	40,43%
DMU14	64,97%	37,28%
DMU15	51,57%	47,98%
DMU16	67,98%	60,81%
DMU17	100,00%	66,55%
DMU18	65,05%	51,81%
DMU19	58,07%	44,34%
DMU20	64,82%	53,93%
DMU21	100,00%	87,35%
DMU22	74,86%	62,22%
DMU23	77,15%	63,91%
DMU24	72,85%	49,82%
DMU25	70,21%	27,63%
DMU26	71,29%	48,80%
DMU27	95,73%	86,49%
DMU28	70,93%	66,88%
DMU29	66,95%	48,35%
DMU30	81,64%	51,87%
DMU31	59,46%	38,64%
DMU32	90,49%	88,70%
DMU33	47,02%	27,96%
DMU34	73,63%	58,03%
DMU35	53,88%	41,10%
DMU36	64,70%	54,65%
DMU37	58,22%	49,55%
DMU38	61,86%	51,54%
DMU39	81,85%	73,89%
DMU40	100,00%	100,00%
DMU41	63,91%	52,00%
DMU42	55,83%	40,16%
DMU43	36,20%	27,59%
DMU44	54,65%	42,65%
DMU45	81,42%	45,92%
DMU46	76,52%	41,81%
DMU47	100,00%	89,25%

The efficiency scores were comparatively analyzed with DEA model and DEAHP models and the results were given in Table 19. 3 of the 6 schools that were previously found effective with DEA model were not considered to be 100% effective with DEAHP model. However, efficiency scores decreased with the addition of weights. It was concluded that healthier and more reliable results were achieved only when these variables were included in the analysis with AHP model rather than giving equal weight values to the input and output variables.

5. CONCLUSION AND RECOMMENDATIONS

Considering that the education system plays a vital role in the development and welfare of countries, conducting studies on the efficiency of educational institutions and improving their organizational structure are urgently required, which, indeed, accounts for a growing number of studies on education system every year. This particular study was conducted to evaluate the efficiency of Anatolian high schools in İzmir and to provide guidance to the ineffective institutions to become effective, and most importantly, to contribute to the education system. This study stands out as the first in its kind to use DEAHP integrated model in assessing the efficiency of Anatolian high schools in İzmir.

In the study, 47 Anatolian High Schools were selected as DMUs in the central districts of İzmir. Afterwards, 3 input and 3 output variables were selected that best represent the high school education processes. The study data were collected in the 2015-2016 academic year and were analyzed with EMS 1.3.0 package program. After identifying and establishing variables and collecting data, the efficiency was measured with DEA model. Finally, weights were assigned to the input and output variables with AHP model, efficiency analysis was repeated with DEAHP integrated model.

The initial measurement with DEA suggested that 6 schools were 100% efficient and the efficiency scores of the 41 schools remained below 100%. It was reported that Namık Kemal High School had the lowest efficiency score with 36,20%. As a result of the analysis, the target value was calculated for DMU27, Gaziemir Anatolian High School. The current number of students attending Gaziemir Anatolian High School was 630. The results suggested that the target value for the number of students was 526 and the number of students should be reduced to increase efficiency. As for the number of teachers and classrooms, the target value was calculated and analyzed with the help of the program and the unit reached 100% efficiency.

In the analysis conducted with DEAHP model, binary comparison matrices were used to assign weights to input and output variables with reference to the expert opinions of four counsellors whose opinions were considered to be consistent and then the efficiency analysis was conducted. It was concluded that the efficiency scores of 3 schools decreased which were previously noted to be efficient according to DEA model, and that only 3 schools were found efficient according to DEAHP model. The average significance values were calculated on the basis of binary comparison matrices of the inputs and outputs generated with the expert opinions of counsellors and it was reported that the three input variables with highest significance values were the number of teachers, number of classrooms and the number of students, respectively. Likewise, three output variables with highest significance values were YGS + LYS success rate, the number of students pursuing a university degree, and the number of graduates, respectively.

As a result, it is recommended that efficient Anatolian high schools maintain their efficiency levels and that inefficient institutions specify their optimum input levels, that is, their target values, by modeling efficient institutions on improving their efficiency as identified with DEAHP model. It is also strongly suggested that these efficiency analyses be repeated at regular intervals to (re)establish target values and conduct further researches to promote the improvement of our education system.

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