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RESEARCH ARTICLE

Financial efficiency of companies operating in the Kosovo food sector: DEA and DEAHP

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ABSTRACT

Data Envelopment Analysis (DEA) evaluates a large number of input and output variables using mathematical programming techniques and analyzes the effectiveness of similar decision making units (DMU). Unlike traditional methods, the most important advantage of DEA is that the weights of input and output variables can be defined by the analyzer. In this study, the limitations of the DEA weights were determined using the AHP, which considers expert opinion. In addition, an alternative judgment scale was used for the Saaty judgment scale, which is used as a standard in the AHP method, and thus a more sensitive analysis was performed. There have been studies dealing with the comparison of judgment scales, but few studies on consistency sensitivity are needed. This point has also been addressed in this study. Subsequently, the financial efficiency of 27 companies operating in the food sector in Kosovo was evaluated with the weight-restricted DEA model, first created using the unweighted DEA model and then the AHP model, and the two models were compared. This paper is the first one of its kind since there are no previous studies regarding the examination of the financial efficiency of companies operating in the Kosovo food sector based on the DEAHP method.

1. Introduction

Determining the performance of companies is important for both company management and investors. Companies have different time periods and different management levels, and therefore have different combinations of input and output. A company with very good profitability in the short term may show poor performance in the long term due to poor marketing policies. Although financial ratios such as return on investments or return on sales reflect the financial performance of the company, they are insufficient to show the overall performance of the company. On the other hand, the biggest shortcoming of efforts to combine by weighting the set of inputs and outputs adopted to show the full performance of the business is that the given weights are subjective [1].

Many inputs are used in most companies (such as several staff, wages, working hours, and advertising budgets). Similarly, output criteria (such as profitability, market share, and growth rate) differ. It is difficult for managers to "determine which units are ineffective" by evaluating many inputs and outputs simultaneously. In this case, using mathematical programming in the solution technique, Data Envelopment Analysis (DEA), in the efficiency measurement of problems with multiple inputs and multiple outputs, offers managers an important tool in determining relative activities [2].

On the other hand, when each of the multiple input and multiple output variables to be used does not have the same importance, studies have been carried out by including these variables in the analysis with the help of the Analytic Hierarchy Process (AHP) method. In addition, DEA is a method that guides managers and decision makers in terms of what should be done to improve the efficiency of relatively ineffective decision-making units [3]. In this way, it has enabled us to achieve healthier results.

DEA has had a wide range of applications since its emergence. In addition to its use alone, its use with other techniques is frequently encountered in the literature. Some of the studies related to the DEAHP method are given below.

Stern et al. [4], concluded that DMUs, which have more than one input and output, used a two-stage method with AHP to make complete sequencing whereas the DEA method lacked. In 2007 Lee et al. [5], the AHP and DEA hybrid approach in their studies and applied in the national energy efficiency plan sector. For the selection of warehouse operator networks, Korpela et al. [6], combined AHP and DEA methods. Sevkli et al. [7], made the supplier selection study of the BEKO company by using the DEAHP approach. Using the AHP-DEA method; Wang et al. [8] conducted a study evaluating the risks of bridge shapes based on previous bridge shapes. Erpolat and Cinemre [9] evaluated the efficiency of notebook computers of different brands and models, with the hybrid method of DEA and AHP. Tseng and Lee [10] measured the relationship between human resource practices and organizational performance variables using DEA / AHP method. In 2017, Keskin and Ulaş [11] investigated the effect of self-criticism on the performance of airports using AR, AHP and DEA. Çetin et al. [12] work was evaluated as a real homework problem to the banking sector and as a generalized assignment problem. In addition, in 2019, Pradhan, Olfati [13] included a detailed literature review of AHP and DEA methods used in their studies.

In addition to the methods used in the studies mentioned above, an alternative scale to the standard scale used in the binary comparison, which is one of the AHP stages, was used in this study. In this way, it has differentiated from many studies and also has the feature of being the first study done with this method in the food sector in Kosovo.

The remainder of the paper is organized as follows. The next Section 2 presents the methodology, and the steps used are given in detail in Section 3. Finally, the conclusions, including the results of the study and suggestions for future studies, are made in the last section.

2. Methodology

Since DEA and AHP methods were used in an integrated way in the study, DEA, AHP and DEAHP methods are described in this section.

2.1. Data envelopment analysis-DEA

Data Envelopment Analysis, which is based on non-parametric, linear programming principles, is a mathematical programming method that can compare relative efficiency between organizations when there are too many inputs and outputs [14]. In other words, Data Envelopment Analysis is a linear programming-based analysis method that measures the relative efficiency levels of (DMU), which has the task of generating similar outputs using similar inputs when multiple inputs and outputs represented by different units become difficult to compare [15].

In DEA, two models work under the constant return assumption (CRS) according to the scale generally used and the variable return according to the scale (VRS) and both are evaluated as input and output side [14]. While input direction models are investigating how the most appropriate input combination should be used to produce a certain output combination most efficiently; output direction models investigate how much output composition can be achieved with a given input combination. The selection of the model to be used in DEA varies according to the scope of the research and assumptions.

The original fractional CRS model Eq. (1) evaluates the relative efficiencies of n DMUs $j=1,\dots,n$ each with m inputs and s outputs denoted by $x_{1j}, x_{2j},\dots, x_{mj}$ and $y_{1j}, y_{2j},\dots, y_{sj}$ respectively [16]. This is done so by maximizing the ratio of a weighted sum of output to the weighted sum of inputs:

$$E_k = Max \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}},$$

s.t.

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1,\ j=1,\dots,n,\ r=1,\dots,s \tag{1}$$

$$u_r, v_i \ge 0,\ \text{for all } r \text{ and } i$$

In model Eq. (1), E_k is the efficiency of DMU_k and u_r and v_i are the factor weights. For computational convenience, the fractional form Eq.(1) is re-expressed in linear program (LP) form as follows which is known as input oriented CRS model:

$$E_k = Max \sum_{r=1}^{s} u_r y_{rk},$$

s.t.

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 1,\quad j=1,\dots,n \tag{2}$$

$$\sum_{i=1}^{m} v_i x_{ik} = 1$$

$$u_r, v_i \ge 0$$

The dual of linear program (LP) model for input oriented CRS model is as follows:

$$Min\, E_k$$

s.t

$$\sum_{j=1}^{n} \lambda_{jk} x_{ij} \le E_k x_{ik}\quad i=1,\dots,m \tag{3}$$

$$\sum_{j=1}^{n} \lambda_{jk} y_{rj} \ge y_{rk}\quad r=1,\dots,s$$

$$\lambda_{jk} \ge 0$$

Despite many modified models since the emergence of DEA, the most widely known and used model is the Input-oriented CRS model [17].

2.2. Analytic hierarchy process –AHP

The Analytical Hierarchy Process (AHP) is a multi-criteria decision making method that has been widely used since the 1970s. It separates the existing problem into small pieces and examines the effects of the pieces on each other. As a result of this process, the weight of the parts and the order of importance of the parts are obtained. For this purpose, a comparison scale that quantitatively evaluates the effects of parts on each other was created. Parts of the problem are compared in pairs and the effects of each part on the target are obtained quantitatively. AHP method can be used for measuring in both social and physical areas [18].

These pairwise comparisons are made using a verbal scale. Subsequently, these verbal comparisons are converted into proportional evaluations using a one-to-one matching method with a numerical scale. Although many numerical binary comparison scales have been proposed since the date when the AHP method was introduced [19] the most widely used scale today due to its simplicity and clarity is Saaty (1980) [20] also known as the "Basic Scale", the 1-9 linear scale.

Table 1. Saaty's comparison scale

Definition	Importance
Equal importance	1
Weak dominance	3
Strong dominance	5
Demonstrated dominance	7
Absolute dominance	9
Intermediate values	(2,4,6,8)

Saaty (1994) argues that it is the best scale representing weight ratios. However, while some scholars working in this field deal with objectively measurable alternatives, AHP treats decision processes as subjective issues. Salo and Hämäläinen [21], demonstrated the superiority of the balanced scale by comparing only two elements. Choosing the appropriate scale is a difficult and frequently discussed issue. Some scientists claim that the choice depends on the person and the decision problem [22]. However, there is no exact rule as to which scale is better for certain decision-making problems, types of alternatives, or criteria.

In this study, comparisons made with traditional and balanced scales were used in the application part and the weights of the scale, and by comparing the results, the weights of the scale giving more consistent results were used.

Table 2. Pairwise comparison decision matrix

Scale Name	Parameter (x)	Mathematical Description	Approximate Scale Value
Traditional AHP-linear (Saaty 1980)	$\{1,2,...,9\}$	x	1; 2;3; 4; 5; 6;7;8; 9
Balanced (Salo and Hämäläinen, 1997)	$\{0.5,0.55,...,0.9\}$	$\frac{x}{(1-x)}$	1;1.22;1.5;1.86; 2.33;3;4;5.67;9

With the numerical values obtained as a result of binary comparisons, a square matrix called the "Binary Comparison Matrix" (BCM) is created. These numerical values in BCMs are used to calculate the local importance (weight) of all the compared elements within their groups.

With the number of variables to be evaluated, the binary comparison matrix is formed as shown below;

$$A=(a_{ij})=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & \cdots & \cdots & a_{nn} \end{bmatrix}, \quad \begin{matrix} i,j=1,\dots,n \\ a_{ij}>0 \end{matrix}$$

If $a_{ij}=1/a_{ji}$ and $a_{ii}=1, a_{ij}=a_{ik}a_{kj}, i,j,k=1,...,n,$ is equal, Matrix A is perfectly consistent if equality is achieved, inconsistent if not [8].

Their local weights are the cornerstone of the mathematics behind the AHP method; otherwise, sorting would not be possible. The most common methods used to calculate these values are the Eigenvalue Method and the Logarithmic Least Squares (also known as the Row Geometric Mean) Method. When the matrices are consistent, each method calculates the same priorities. After determining the local weights, the consistency of the decision maker's evaluations is evaluated for all (or at least doubtful) BCMs. The most widely known evaluation method is the Eigenvalue Method; the second most widely known method is the Geometric Consistency Index. Due to its nature, AHP contains a certain degree of inconsistency. A consistency value of up to 0.10 in the consistency ratio (CR) is acceptable. A CR value greater than 10% indicates that the decision maker should review its decisions [5].

2.3. DEA and AHP integrated models

By using the data envelopment analysis method, quantitative inputs and outputs are used to evaluate the effectiveness of decision-making units. Since the inputs and outputs determined for use in the analysis are not always equally important, instead of giving equal weight to the variables, it is extremely important to determine their advantages over each other [23]. In this case, the AHP method was used for weighting between inputs used by DMUs and between hemp of outputs produced with them. The Data Envelopment Analytical Hierarchy Process integrated method created in this way was first proposed by Ramanathan [24].

The constraint to be created for the weight-constrained data envelopment analysis is to use the analytical hierarchy process method and provide it with the weights obtained by including expert opinion in the analysis. The matrix of binary comparisons to be used in this constraint and its mathematical representation are as follows;

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1s} \\ \vdots & \ddots & \vdots \\ a_{s1} & \cdots & a_{ss} \end{bmatrix}$$

If the AHP binary comparisons matrix created for the entries is A, the weight constraints of the inputs are as follows:

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

$$\vdots$$

$$\frac{u_{s-1}}{u_s} \geq a_{(s-1)s} \rightarrow u_{s-1} \geq a_{(s-1)s}u_s \rightarrow u_{s-1} - a_{(s-1)s}u_s \geq 0.$$

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

If matrix B is the AHP binary comparisons matrix created for the outputs, the weighting restrictions for the outputs are as follows:

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

$$\vdots$$

$$\frac{v_{m-1}}{v_m} \geq b_{(m-1)m} \rightarrow v_{m-1} \geq b_{(m-1)m}v_m \rightarrow v_{m-1} - b_{(m-1)}v_m \geq 0.$$

By writing these inequalities in accordance with linear programming, the problem can be solved with simplex or similar algorithms [9].

The application stages for DEAHP method applied in this study are shown in Figure 1.

3. Evaluation of financial activities of 27 firms operating in the food sector in Kosovo

3.1. Purpose of the study

The food industry is one of the most important sectors for Kosovo's economy and most of the products in this sector are produced as domestic products. After the last war in Kosovo, the economic situation has caused damage to the food sector. One of the most important problems facing the food sector in Kosovo today is the lack of technology to increase the food and production capacity and the lack of appropriate marketing strategy that will affect the business plan due to insufficient funds. In recent years, new investment opportunities have emerged, and these investments have enabled the production of products such as milk and dairy products, fruits and vegetables, and cereals with new technology.

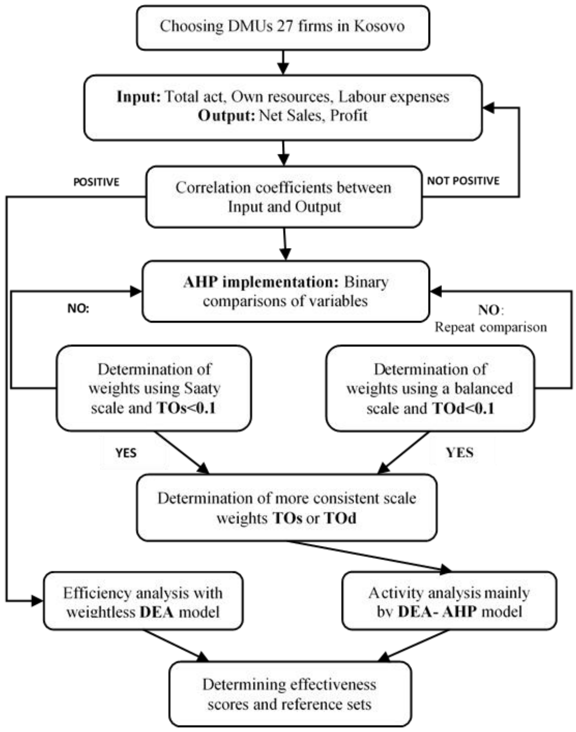

Figure 1. DEAHP method algorithm flow chart

It is thought that this study can shed light on the limited number of studies on the efficiency of the food sector in Kosovo, and also in order to increase food production companies, production and food sales and efficiency.

In this study, the financial efficiency of companies operating in the Kosovo food sector was measured by using DEA and DEAHP methods. The purpose of choosing this method is to ensure that the opinions of experts in their fields are included in the analysis while determining the financial efficiency of the companies, and at the same time to obtain healthier results. 27 companies active in this sector were included in the study. Within the scope of the study, the model and application stages in which DEA and AHP methods are used in an integrated manner are briefly explained.

3.2. Selection of DMUs

Taking into account the conditions of homogeneity of decision-making units and having the same inputs and outputs, 27 companies operating in the Kosovo food sector, with access to the balance sheet and income statement data from the Ministry of Economy and Finance, were selected as DMU.

3.3. Establishing input and output variables in DMUs

In data envelopment analysis, since different input and output groups will take different efficiency values for the same decision unit, it is necessary to determine causally related and meaningful input-outputs to the production process. For this reason, taking into account the ratios of their financial structures while conducting productivity analysis based on the financial performance of companies operating in the food sector the input and output variables of the model were determined as in Table 3.

Table 3. Input and output variables

INPUTS	OUTPUTS
Own Resources	Net Sales
Active Total	Profit
Labour Expenses	

The data of these input and output variables have been obtained from the balance sheet tables on the official website of the Ministry of Finance. Before conducting the efficiency analysis, the correlation coefficients between input and output variables will be examined first. If all the coefficients are positive and strong, the analysis phase will start.

Table 4. Correlation analysis results between ınput and output variables

	Own Resources	Active Total	Labour Excpenses	Net Sales	Profit
Own Resources	1.00				
Active Total	0.76	1.00			
Labour Excpenses	0.58	0.92	1.00		
Net Sales	0.64	0.75	0.85	1.00	
Profit	0.85	0.48	0.45	0.45	1.00

When Table 4 is examined, it is seen that there is a positive correlation between input variables and output variables. This shows that an increase in any input variable will provide an increase on the output variable. There should be no negative correlation between input and output variables.

3.4. Determining relative weights of input and output variables: application of AHP method

With the AHP method, the weights of input and output variables are determined in this section. To determine these weights, a "Financial Performance Efficiency Analysis Survey of Companies in the Food Sector" and dual criteria comparisons have been prepared. The questionnaire form prepared was done by the face-to-face interview method with the economists of the companies operating in Kosovo and included in the study. The interview was conducted with four experts, and the weight of each variable was calculated with the Expert Choice package program according to their answers to the questionnaires.

Here, the comparisons made using the traditional and balanced scale values proposed by Saaty and the weights obtained by taking their geometric averages are shown below. The experts participating in the questionnaire could not determine their opinion only according to the Saaty scale, it was calculated by making the necessary changes to the balanced scale. Table 5 shows the percentage importance values, ranks and CR values obtained by using both scales of the input variables, calculated based on the pairwise comparison matrices. One of the important criteria that AHP takes into account is CR. As stated at the beginning, it was stated that this ratio was smaller than 0.10, which was sufficient for the validity of the pairwise comparison. In a study, he interpreted the performance of the scales using many scales and several performance measurement methods [25]. Measured Scale Lower CR, one of the scale performance measurement methods used: This performance measure represents the percentage of trials that have lower CR values when generated by measured scale rather than fundamental scale. According to the CR values in Table 5, we can say that Balalanced scala results have better performance.

Table 5. Input weights obtained with two scales

Input variable	Weights and rank			
	Saaty scale	Rank	Balanced scale	Rank
Own Resources	0.498	1	0.418	1
Active Total	0.187	3	0.252	3
Labour Expenses	0.315	2	0.330	2
Consistency Ratio	***0.0025***		***0.0005***	

- According to the Saaty scale, when the average percentage weights of the input variables are examined, among the input variables, "Own Resources" are in the first place with an importance value of 49.8%, "Labour Expenses" take second place and "Active Total" take the last place.
- According to the balanced scale, when the average percentage weights of input variables are analyzed, "Own Resources" is again in the first place with a 41.8% significance value.

In addition, the closeness of the priority vectors obtained with both scales according to the Saaty compatibility index was examined.

Even when vectors are not identical, they can sometimes be considered close to each other. According to Saaty (2005), "when two vectors are close, we say they are compatible". The Saaty Compatibility Index, S, was the first developed measure of compatibility between priority vectors. This index uses the concept of the Hadamard Product, the element-wise product of two matrices [26].

The Saaty Compatibility Index, S, between vectors $\boldsymbol{x}$ and $\boldsymbol{y}$ is obtained with Equation. $S = (1/n^2)e^T A \bullet B^T$ e where n is the number of elements of the vectors, $\boldsymbol{e}$ is a column-matrix with all elements equal to 1, $a_{ij} = x_i/x_j$, $b_{ij} = y_i/y_j$ and $\bullet$ is the Hadamard Product operator [27].

One desirable property of a consistency index is that it should indicate that a vector is completely compatible with itself. For identical vectors, $S=1$. If $S \leq 1.1$, the two vectors are said to be consistent; otherwise, not.

Table 5 has two priority vectors obtained for the criteria using the Saaty and balanced scale. The corresponding elements of vectors 1 and 2 appear close to each other based on a cursory examination of their differences. So S = 1.037 for Vector 1 and 2 indicates that they are indeed compatible.

According to the percentage weights of the input variables according to both scales, the rankings or rankings of importance are the same. The slight variation in the weight distribution according to the scale is due to the inconsistency rates accumulated in the pairwise comparisons. Pairwise comparison matrices with a balanced scale had higher consistency sensitivity and significantly reduced the weight ratios of the criteria. For example, the relative ratio of "Own Resources" and "Active Total" input criteria obtained by using the Saaty scale is found as (0.498/0.187) = 2.66, while with the balanced scale (0.418/0.252) =1.66. Although the absolute differences in weight ratios are small and the ranks are the same as expected, the AHP method takes into account relative ratios, such that the above comparison illustrates one of the situations where significantly different results can occur when using different scales [28].

As stated in this study, since consistency sensitivity will be taken into consideration, input weights obtained with a balanced scale were used to be used in the next steps.

The operations performed to obtain the weights of the input variable are also performed for the output variable and the weights are determined. Since there are only two variables here, there is no inconsistency, so little difference is observed in the comparisons made with two scales.

Table 6. Output weights obtained with two scales

Output variable	Weights and Rank			
	Saaty scale	Rank	Balanced scale	Rank
Net Sales	0.362	2	0.431	2
Profit	0.638	1	0.569	1

When the average percentage weights of the output variables required for the second analysis are examined, among the output variables, "profit" is more important than the "net sales" variable with an importance value of 63%.

The weight of each variable was calculated using the expert choice package program in line with the answers given by the financial experts. Variable weights were calculated using the geometric mean method in solving the eigenvalue of the binary comparison matrix.

The matrix of geometric means of four expert opinions for input and output variables is given below. Based on this, it is given below to be used when analyzing the financial performance efficiency with the DEA weighted method in the next steps.

A pairwise comparison matrix is adapted according to the Saaty scale values.

Inputs	v_1	v_2	v_3
v_1	1.00	2.66	1.58
v_2	0.38	1.00	0.59
v_3	0.63	1.68	1.00

Outputs	u_1	u_2
u_1	1.00	0.57
u_2	1.76	1.00

$$\frac{v_1}{v_2} \geq 2.66 \Rightarrow v_1 - 2.66v_2 \geq 0\ ,\qquad \frac{u_1}{u_2} \geq 0.57 \Rightarrow u_1 - 0.57u_2 \geq 0\ .$$

$$\frac{v_1}{v_3} \geq 1.58 \Rightarrow v_2 - 1.58v_3 \geq 0\ ,$$

$$\frac{v_2}{v_3} \geq 0.59 \Rightarrow v_2 - 0.59v_3 \geq 0\ ,$$

A pairwise comparison matrix is adapted according to the Balanced scale values.

Inputs	v_1	v_2	v_3
v_1	1.00	1.66	1.27
v_2	0.60	1.00	0.76
v_3	0.79	1.31	1.00

Outputs	u_1	u_2
u_1	1.00	0.76
u_2	1.32	1.00

$$\frac{v_1}{v_2} \geq 1.66 \Rightarrow v_1 - 1.66v_2 \geq 0\ ,\qquad \frac{u_1}{u_2} \geq 0.76 \Rightarrow u_1 - 0.76u_2 \geq 0\ .$$

$$\frac{v_1}{v_3} \geq 1.27 \Rightarrow v_1 - 1.27v_3 \geq 0\ ,$$

$$\frac{v_2}{v_3} \geq 0.76 \Rightarrow v_2 - 0.76v_3 \geq 0\ ,$$

The constraints obtained will be included in the DEA models to be calculated and the weighted DEAHP model will be re-run with the EMS V1.3 program developed by Holger Scheel [29].

3.5. Efficiency analysis with DEA and DEAHP

The purpose of the model for input from DEA models is to investigate the most appropriate input combination. Since the main purpose of this study is to determine how much decrease (increase) should be made in the amount of input in order to improve the efficiency of ineffective firms, the input-repetitive DEA model was used under the assumption of constant return to scale. EMS V1.3 (Efficiency Measurement System) package program was used for efficiency analysis.

DEA analysis is made with the data obtained from the accessible Balance Sheet tables. Here, DMUs will form the companies in question and the naming will be DMU. The input variables are the finance data Own Resources, Active Total, Labour Excpenses and output variables Net Sales, Profit.

Table 7. Efficiency scores and reference groups

Firms	DEA %ES	Reference Groups *Benchmarks*	DEAHP %ES	Reference Groups *Benchmarks*
DMU1	64.45%	6 (2.37) 16 (0.18) 20 (0.99)	46.67%	6 (3.94)
DMU2	61.73%	6 (2.79) 7 (0.91)	41.47%	20 (2.70)
DMU3	20.57%	6 (0.06) 7 (0.11)	11.35%	20 (0.12)
DMU4	19.86%	6 (0.08) 7 (0.09)	12.00%	20 (0.12)
DMU5	99.72%	6 (0.94) 16 (0.00) 20 (0.17)	98.74%	6 (0.93) 20 (0.18)
DMU6	**100.00**	**13**	**100.00%**	**16**
DMU7	**100.00**	**6**	63.64%	6 (0.22) 20 (0.51)
DMU8	90.87%	6 (0.18) 7 (0.57) 23 (0.04)	58.96%	6 (0.30) 20 (0.32)
DMU9	53.66%	6 (0.09) 7 (0.15)	22.58%	6 (0.13) 20 (0.08)
DMU10	67.50%	6 (0.21) 11 (0.04)	28.86%	6 (0.22)
DMU11	**100.00**	**4**	45.82%	6 (0.32)
DMU12	63.97%	6 (0.38) 7 (0.04)	33.45%	20 (0.31)
DMU13	86.34%	11(1.01) 16 (1.36)	51.12%	6 (4.05)
DMU14	91.94%	11(0.79) 16 (1.15)	53.59%	6 (3.39)
DMU15	91.75%	6 (0.02) 11 (0.16) 16 (1.10)	56.63%	6 (3.08)
DMU16	**100.00**	**12**	62.99%	6 (2.74)
DMU17	64.66%	16(0.22) 20 (0.98)	47.74%	6 (1.55)
DMU18	55.79%	16(0.15) 20 (0.63)	35.34%	6 (0.15) 20 (0.65)
DMU19	73.00%	16(0.14) 20 (0.53)	41.48%	6 (0.10) 20 (0.57)
DMU20	**100.00**	**10**	**100.00%**	**16**
DMU21	88.07%	6 (0.37) 20 (0.47)	79.75%	20 (0.74)
DMU22	94.85%	6 (0.83) 20 (0.06)	83.54%	20 (0.68)
DMU23	**100.00**	**1**	73.49%	20 (0.61)
DMU24	33.40%	16(0.32) 20 (1.28)	20.16%	20 (1.55)
DMU25	33.93%	16(0.42) 20 (1.34)	19.18%	20 (1.69)
DMU26	59.53%	6 (3.63) 16 (0.52)	36.75%	6 (3.92)
DMU27	30.03%	16(0.10) 20 (1.56)	25.89%	6 (0.39) 20 (1.36)

The model was run as input-oriented in the EMS program; The scale is based on fixed returns to scale. Efficiency analysis results of the DEA method and DEAHP methods are comparatively given in Table 7.

Table 7. shows the efficiency measurement results of the DEA method and DEAHP methods comparatively consisting of five columns. For firms that are decision units in the first column, efficiency scores (% ES) and “Benchmarks” reference groups are included in the second and third columns as percentages of DEA method. The fourth and fifth columns contain efficiency scores and reference groups of DEAHP method. Firms with a 100% ES value are effective, while those with an ES value below 100% are ineffective. In the “Benchmarks” column, there are reference groups of inactive companies (referenced companies) and information showing the number of times that active companies are referenced by inactive companies. As can be seen from Table 7, 4 out of 6 companies found effective in the analysis made with DEA method were not found to be 100% effective in the analysis made with DEAHP method. However, it is seen that efficiency scores decrease with the addition of weights. Here, instead of giving equal weight to input and output variables, including the weights of these variables in the analysis with the help of AHP method provides us to reach healthier and more reliable results.

The steps to be taken for the ineffective companies, examined in this study, to become effective are shown below with an example. Here, the results obtained with the DEAHP method will be used as it performs a more sensitive analysis. DMU6 is the most important company in the reference group that the companies below the activity limit will take samples to be fully effective. The firm with the lowest efficiency score is DMU3 with an efficiency score of 11.35%. In this input-oriented method, while keeping the output level constant, the input amount is aimed to be optimum and it is determined how much the inputs should be reduced for the ineffective DMU to be effective. The target value can be found by using the percentages in the "Benchmarks" column for the improvements (reductions) of DMU27 in its inputs.

The target value is calculated as follows:

$$DMU27_i = (0.39 \times DMU6_i) + (1.36 \times DMU20_i)$$

$DMU27_i$: DMU1’ Target value for the i’ th input

$DMU6_i$: DMU6’ Current value for the i’th input

$DMU20_i$: DMU20 Present value of the i’th input

0.39 : DMU6’weight

1.36 : DMU20’weight

$$DMU27_1 = (0.39 \times 4712000) + (1.36 \times 201000) = 2111040$$

As a result, the DMU27 firm has to make a 55% reduction in order to reach the target value of 2111040 calculated euro of 4712000 euro, which is the current value of the first input "own resources". In this way, the ineffective DMU will be transformed into active as a result of the improvements to be made.

Using the values in the "Benchmarks" column of other inactive decision units, calculations can be made similarly, and the target values and improvement rates of decision units can be determined.

4. Conclusion

In this work, DEA has been conducted by taking into account the relative activities of 27 companies operating in the food sector in Kosovo. DEA was made with 3 inputs and 2 outputs in the study. The input variables are the financial data: own resources, active total, labour expenses, and output variables. For the analysis, the EMS 1.3.0 package program, one of

DEA's specialized software tools, was used.First, the efficiency of the firms according to the CCR model for input was found, and their efficiency averages were also examined. Later, weights were assigned to input and output variables with the help of the analytic hierarchy process method, and efficiency analysis was repeated with data envelopment and the analytic hierarchy process integrated method. In addition, the *Balanced scale*, which is thought to reduce the inconsistencies caused by the *Saaty scale* used for AHP pairwise comparison, was included in the study. In this way, no other study was found in the food industry using different scales in the DEAHP integrated method.In the last stage, the targets that should be achieved by ineffective companies to improve their productivity have been determined.

As a result of the efficiency measurement with data envelopment analysis, 6 companies were found effective, while the efficiency scores of the other 21 companies were found to be below 100%. In the analysis made with the DEAHP method, weights were assigned to the input and output variables with the pairwise comparison matrices obtained with the help of the opinions of four statisticians, using the more consistent balanced scale, and the efficiency analysis was repeated.

As a result of the analysis, it was seen that the efficiency scores of DMU7, DMU11, DMU16 and DMU23 companies, which are effective with the DEA method, decreased by 63.64%, 45.82%, 62.99% and 73.49%, respectively, and it was determined that only DMU6 and DMU20 companies were effective. In other words, while the average efficiency score was 72% according to DEA results, this score decreased to 50% according to DEAHP results. The reason for this is that most of the data belonging to the input variables are not taken into account under the DEA method, which invites incomplete conclusions from sensitivity and incomplete interpretations of these results. This means that weighted DEAHP methods take into account the values of all input and output variables without loss, and performing the analysis in this way reduces the margin of error in producing more accurate results.

As a result, it is recommended that active companies continue to maintain their activities and that inactive companies determine the best input amounts, ie target values, by taking reference companies as a result of the analyzes made with the DEAHP method and making improvements in this direction.

Repeating these efficiency analyses not only once but regularly, finding target values and conducting studies on this subject will contribute to the improvement of the financial efficiency of companies. In addition, in future research, we are considering combining this work with other decision making methods such as DEA and fuzzy AHP, analytical network process (ANP). We will also compare the results found in this paper.

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