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COMPARATIVE ANALYSIS OF FINANCIAL EFFICIENCIES WITH DATA ENVELOPMENT ANALYSIS (DEA) AND MULTI-ATTRIBUTE UTULITY THEORY (MAUT) METHODS

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VERİ ZARFLAMA ANALİZİ (VZA) VE ÇOK NİTELİKLİ FAYDA TEORİSİ (MAUT) YÖNTEMLERİ İLE FİNANSAL ETKİNLİKLERİN KARŞILAŞTIRMALI ANALİZİ

Abstract

The main purpose of this study is to perform financial analysis of textile companies with Multi Criteria Decision Making (MCDM) methods. "Which MCDM method is most suitable for a given problem?" is an important question in the literature. The study was carried out with different MCDM methods and the results were compared and it was aimed to make a small contribution to the question in the literature. In addition, providing a perspective to the stakeholders and investors of textile sector is another aim of the study. In this study, were attempt to determine the financial activities and performances of 22 firms in the textile sector, which were traded in BIST (Borsa Istanbul) during 2008–2015. The efficiency analysis was done by DEA method using the financial indicators of the firms. Furthermore, the MAUT method was applied to determine financial performance. In this study, the efficiency and performance orders obtained with the DEA (BCC), DEA (CCR), and MAUT methods were examined together and then compared. Accordingly, it was seen that BISAS was the most successful company during the whole period for the three methods. The following companies were found to be ESEMS, SNPAM, ATEKS, and KORDS.

Keywords: Efficiency, Performance, Textile Sector, DEA, MAUT, Entropy.

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Öz

Bu çalışmanın temel amacı, Çok Kriterli Karar Verme (ÇKKV) yöntemleri ile tekstil firmalarının finansal analizinin yapılmasıdır. "Verilen bir problem için hangi ÇKKV yöntemi en uygundur?", literatürde yer alan önemli bir sorudur. Çalışmada farklı ÇKKV yöntemleri ile analiz yapılmış ve sonuçlar karşılaştırarak, literatürdeki soruya küçük de olsa bir katkı yapmak amaçlanmıştır. Ayrıca, tekstil sektörü paydaşlarına ve yatırımcılarına bir perspektif sunulması, çalışmanın diğer bir amacıdır. Bu çalışmada, 2008-2015 yılları arasında BIST'de (Borsa İstanbul) işlem gören tekstil sektöründeki 22 firmanın finansal faaliyet ve performanslarını belirlemeye çalışılmıştır. Etkinlik analizi, firmaların finansal göstergeleri kullanılarak VZA yöntemi ile yapılmıştır. Ayrıca, finansal performansı belirlemek için MAUT yöntemi uygulanmıştır. Bu çalışmada VZA (BCC), VZA (CCR) ve MAUT yöntemleri ile elde edilen etkinlik ve performanslar birlikte incelenmiş ve karşılaştırılmıştır. Buna göre üç yöntem için BİSAS'ın tüm dönem boyunca en başarılı şirket olduğu görülmüştür. Bunu ise ESEMS, SNPAM, ATEKS ve KORDS firmaları takip etmiştir.

Anahtar Kelimeler: Etkinlik, Performans, Tekstil Sektörü, VZA, MAUT, Entropi.

1. Introduction

A firm's investment in foreign markets, the rise of the boundaries between the markets, and increasing competition in communication and technological developments have made it necessary to manage resources effectively and efficiently. This is directly related to efficiency and productivity that firms with the potential for development in the entry of foreign investors into the countries catch the opportunities arising from the competition and manage the development process. Therefore, efficiency and productivity measures help companies measure their level of achieving their goals. Thus, companies can take steps to determine what level they have reached in regards to their targets and what measures should be taken to address the factors that cause a departure from the efficiency. This study aims to determine efficiency based on the financial performance of firms with the help of financial ratios.

The aim of the study is to measure and compare the financial activities of selected textile sector firms traded in the Borsa Istanbul; the second part is given in the literature on the subject after the Introduction. In the third part, Data, DEA and MAUT are explained. In the fourth chapter, the results of the analysis of the firms' financial efficiency over the years are explained as a comparative. In the fifth section, the conclusions and suggestions reached are mentioned.

2. Literature Review

Many studies in the literature measure the efficiency level of firms with the DEA method. In this regard, detailed information can be sought by Atıcı et al. (2016) on the study of the application of the DEA method in many sectors in Turkey. On the other hand, a limited number of studies that determine performance by the MAUT method are included in the literature. In this context, studies are given in the literature search on the textiles sector with DEA and studies on textile sectors or other sectors for the MAUT method. In 1994, Chandra et al. (1998) determined the performances of firms by DEA method using the data of 29 Canadian textile companies. As a result of analysis, a balanced mathematical model had been developed, which increased efficiency via the balance of the input effect that reduce efficiency. Jahanshahloo and Khodabakhshi (2004) claimed that the Chinese textile sector has tried to determine the efficiency of the sector with the number of employees and the amount of capital as input and the data of 1981-1997 period using the production amount as the single output with the DEA method.

Kayalıdere and Kargın (2004) revealed that the financial activities of the 27 textile and 15 cement companies traded on the IMKB (İstanbul Menkul Kıymetler Borsası) were determined by the DEA method with the 2002 year data. Çetin (2006) determined the financial performance and financial efficiencies of the 22 companies in the textile sector in the IMKB for the year 2004 by DEA. As a result of empirical analysis, it has been determined that four textile companies are efficient. According to Kayalı (2009), the efficiencies of 29 textile firms among the biggest companies operating in the textile products sector, determined by Fortune Turkey's "500 largest companies in Turkey" study, were measured by DEA method. It has been determined that the average technical efficiency of the sector is 57% in terms of profitability.

In the study of Yenilmez and Girginer (2012), the export efficiencies of five companies operating in Eskisehir Organized Industrial Zone were determined by DEA with 2008–2009 period data. As a result of the analysis, it was determined that the Sarar Company proved efficient every two years, but the Buzlu Konfeksiyon Company was only efficient in 2009. According to Yayar and Çoban (2012), using the 2008 and 2010 data of 25 companies operating in the ISO (Istanbul Chamber of Industry) 500 textile and apparel goods industry, their financial efficiencies were determined by the DEA method. In this study, the CCR (Charnes, Cooper, Rhodes) model with constant returns to scale and BCC (Banker, Charnes, Cooper) and the model with variable return to scale according to the input oriented scale were used. According to the results of empirical analysis, four companies in the textile industry and two firms in the clothing industry were found efficient in 2010, according to the CCR model. On the other hand, according to the BCC model, 11 companies in the textile industry, and four firms in the apparel industry were found efficient in 2010. Kahveci (2012) evaluated the export performances of firms on the basis of CBRT (Central Bank of the Republic of Turkey) sector accountants' 2002-2008 financial data of textile enterprises via a resource-based strategy using the DEA method. Öztürk and Girginer (2015) used DEA and AHP (analytical hierarchy process) methods to measure and evaluate the export efficiencies of 30 firms from textile and apparel companies, which are included in the list of ISO (Istanbul Chamber of Industry) 500. As a result of the analysis, according to the export efficiencies of 2012, four textile companies are efficient.

In order to manage the intense workload of the US Emergency Management Authority, Ashour and Kremer (2013) analyzed the data by using the fuzzy analytical hierarchy process / MAUT method and examined the possibility of simulating them according to emergency situations. Thus, the performance of the emergency management departments will be measured on a departmental basis. Alp et al. (2015) examined the corporate sustainability performance of the Linde Company using its 2009–2012 period data via the MAUT method. According to the analysis results, economic and social sustainability performances have an increasing tendency, but environmental sustainability performance has been found to be unstable. According to Ömürbek et al. (2016), the criteria of capital, stock price, market value, sales revenue, number of employees, net profit margin, current ratio, net profit / capital, net profit / sales, and net sales / number of employees six automotive companies whose shares are traded in the IMKB are using only 2014 year data to determine their financial performance. This study compares financial performances separately determined by the entropy-based weighting MAUT and SAW (Simple Additive Weighting) methods. In both methods, the performance of the same firms was found to be in the first three ranks.

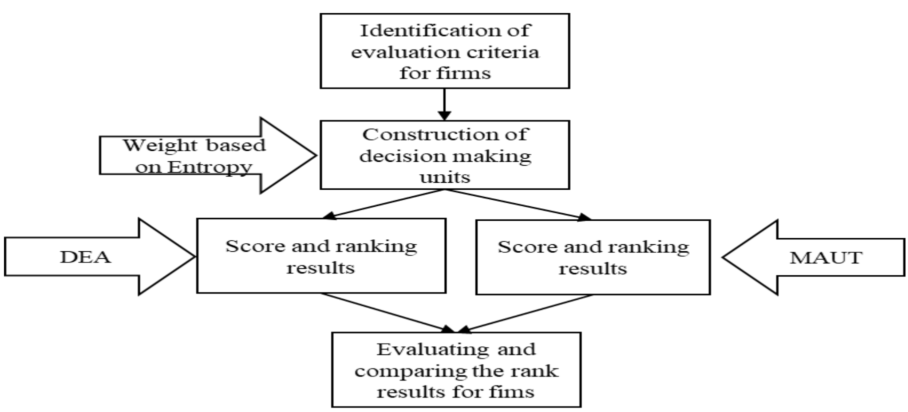
3. Data and Methodology

Twenty-two private equity companies publicly traded on BIST for which the financial statements are available for eight annuals from 2008 to 2015 were identified in order to assess textile firms' financial performance. The financial performance of Akın Textile (ATEKS), Arsan Textile (ARSAN), Bilici Investment (BLCYT), Birko Textile Goods (BRKO), Birlik Textile Goods (BRMEN), Bisaş Textile (BISAS), Bossa (BOSSA), Dagi Clothing (DAGI), Derimod Leather (DERIM), Desa Leather (DESA), Esem Sport Clothing (ESEMS), Hatay Textile (HATEK), İDAŞ (IDAS), Karsu Textile (KRTEK), Kordsa Global (KORDS), Lüks Kadife (LUKSK), Menderes Textile (MNDRS), Mensa Textile Goods(MEMSA), Söktaş (SKTAS), Sönmez Cotton (SNPAM), Yataş (YATAS), and Yünsa (YUNSA) will be analyzed in this study. The data for the study were obtained from the financial statements on the public disclosure platform website.

In this study, in order to measure the firms' efficiencies, the DEA method will be used; in the case of ranking firms' financial performances, the MAUT method will be used, which is in MCDM (multiple criteria decision making) methods. With DEA, it will be determined whether the firms are efficient for each year of the research period, and the results obtained with the MAUT method will be comparatively evaluated. The steps to be followed in this frame are schematically shown in Figure 1. On the other hand, the process of identifying and evaluating effectiveness and performance includes the following steps:

1. Relevant criteria have been set to determine the activities of the companies.
2. For each criterion, the weights based on the entropy weighting method were obtained separately for each year.
3. According to DEA and MAUT methods, the scores and orders of alternatives (years) were determined separately.
4. Scoring and ranking obtained by both methods will be evaluated comparatively.

Figure 1: Evaluation Procedure



The performance criteria and content used to analyze the financial performance are presented in Table 1 (Kula and Özdemir 2007: 63-64; Kula et al. 2009: 195; Başkaya and Öztürk 2012: 184; Erdoğan and Yıldız 2015: 136; Ömürbek et al. 2016: 242; Çetin 2006: 266).

Table 1: Criteria of Inputs and Outputs

INPUTS		**OUTPUTS**	
Current Ratio	Current Assets / Short Term Liabilities	Net Profit Margin	Net Income / Sales
Acid Test Ratio	(Current Assets – Inventories) / Short Term Liabilities	Return on Assets	Net Income / Total Assets
Financial Leverage Ratio	Liabilities / Total Assets	Return on Equity	Net Income / Equity
Receivable turnover in days	Average Recievables * Days in the year / Sales		
Inventory turnover in days	Average Inventory * Days in the year / Cost of goods sold		

In this section, information about DEA and MAUT methods is given, and the steps of the analysis are explained with mathematical notation.

3.1. Data Envelopment Analysis

It is complex to measure the efficiency of any organization using multiple inputs and generating multiple outputs. CCR described a nonparametric approach to measure efficiency in such situations (Charnes et al. 1978: 429-444). This technique is known as DEA. DEA is a linear programming technique that is used to estimate the relevant technology over the production possibility set on the basis of what is observed. The production possibility set is defined as the set of input–output combinations. The boundary of this set, reflecting the greatest amount of output that can be produced from a given amount of input, defines the relevant technology or production function. Based on this, it is then possible to compute the efficiency score of a given decision-making unit (DMU, here Textile firms), a measure of its relative distance to the efficient frontier. DEA is a relatively new way of calculating efficiency of comparable homogeneous organizations; for an extensive description of this technique, the reader is referred to existing papers and textbooks on the subject (Emrouznejad et al. 2008: 151-157; Ray 2004; Cook and Seiford 2009: 1-17; Charnes et al. 1998).

There are some most striking advantages of DEA over other efficiency measurement methods. First, DEA allows measurement of efficiency without having to specify in advance either the form of production function or the weights for inputs and outputs used. Second, it obtains no measurement error or statistical noise, which contributes to accuracy of the result. Third, it simultaneously considers multiple inputs and outputs. That is, DEA is a generalization of total factor productivity (TFP) methods. Thus, DEA is a flexible and important tool to measure efficiency of firms. DEA comes from its property to envelop all points on or below a production frontier line. It is a measure of multifactor productivity growth.

DEA models can be classified by two criteria: type of scale effects and model orientation. The first criterion determines the assumptions concerning the scale effects accepted in the model constant returns to scale (CRS) or variable returns to scale (VRS). The CRS surface is represented by a straight line that starts at the origin and passes through the first DMU that it meets as it approaches the observed population. The models with CRS envelopment surface assume that an increase in inputs will result in a proportional increase in outputs. The CCR model of DEA is based on the CRS assumption. The VRS surface envelops the population by connecting the outermost DMUs. The VRS model allows an increase in input values to result in a non-proportional increase of output levels. The BCC model of DEA is based on the VRS assumption (Charnes et al. 1978: 429-444; Ray 2004; Banker et al. 1984: 1078-1092).

The model orientation approach indicates whether the objective is the minimization of input(s), such as the cost of production, so called the input-oriented model, or the maximization of outputs, so called the output-oriented model.

One point to be noted here is that the term “relatively efficient” means that the DMUs are efficient in relation to other DMUs in the sample. The CCR model allows the respective DMU to adjust its own weights accordingly so that it becomes relatively efficient. Thus, the efficiency score is the ratio of the weighted set of inputs to the weighted set of outputs.

Efficiency = (weighted sum of outputs) / (weighted sum of inputs).

In the CCR model, we assume that there are n DMU to be evaluated. Each DMU consumes varying amounts of m different inputs to produce s different outputs.

In DEA, different mathematical models are used (Charnes, et al., 1998: 36-39). The output oriented model CCR which will be used in this study is defined as below. Behind the efficiency scores, the model provides the lacks and shortages in outputs and excesses in inputs.

$$Max \quad h_o = \phi_o + \varepsilon\left(\sum_{i=1}^{m} s_j^- + \sum_{r=1}^{s} s_r^+\right)$$

$$Subject \quad to$$

$$\phi_o y_o - \sum_{j=1}^{n} y_{rj}\lambda_j + s_r^+ = 0$$

$$\sum_{j}^{n} x_{ij}\lambda_j + s_i^- = x_{io}$$

$$\lambda,\ s_r^+,\ s_i^- \geq 0$$

$$i = 1,\dots, m \qquad r = 1,\dots, s \qquad j = 1,\dots, n$$

Where the subscript *o* represents the DMU being assessed, and the efficiency score of DMU$_o$ is the scalar variable that represents the possible radial enlargement constant to be applied to all outputs so as to obtain the projected output values, and *xij* and *yrj* denote the input *i*'th and output *r*'th of DMUj, respectively. ε is an arbitrary small "non-Arcimedian" number.

S_i^- =0 and S_r^+ are the slacks in the *i*'th and the *r*'th input and output.

Following the CCR output-oriented model, a CCR efficient DMU, *j*, can be defined to satisfy the following two conditions:

1. ϕ^* =1.0 or 100%, and

2. all S_i^{-*} =0 and S_r^{+*} =0, (i=1,…,m), (r=1,…,s).

The VRS (BCC) model differs from the CCR (CRS) model, as it has an additional constraint $\sum \lambda = 1$.

If most DMUs are efficient, then the ranking of efficient DMUs with respect to each other with the concept of super efficiency is necessary. One of these models is Andersen and Petersen's super-efficiency model.

Andersen and Petersen (1993:1261-1264)'s super-efficiency model can be described in the output-oriented CCR case as follows:

$$
\begin{aligned}
&\max \quad h_o = \phi \\
&Subject\,to \\
&\qquad x_{io} = \sum_{j=1,\neq o}^{n} \lambda_j x_{ij} + S_i^- \\
&\qquad \phi y_{ro} = \sum_{j=1}^{n} \lambda_j y_{rj} - S_r^+ \\
&\qquad \lambda_{j,}\ S_i^-,\ S_r^+ \geq 0 \\
&\qquad j = 1,\dots,n,\ \ i = 1,\dots,m,\ \ r = 1,\dots,s
\end{aligned}
$$

where S_i^- and S_r^+ represent input and output slacks, respectively. For an efficient DMU, ϕ is not less than 1.0 (or 100) and slacks are zero. The only difference between Andersen and Petersen's super-efficiency model and CCR|BCC model is just the omission of DMU, which is being evaluated in the constraints. All of the CCR|BCC inefficient DMUs have the same results on weights and efficiency score by the Andersen and Petersen's süper-efficiency model as those by the CCR|BCC model.

3.2. Multi-Attribute Utility Theory

3.2.1.Weighting

Most of the MCDM methods use criteria weights for determining the importance degree of the criteria. Because the distribution of the weights have a wide influence on the solution, the weighting process is important for MCDM problems. In this process, the decision-maker should be accurate and simple but not contradict the essential theoretical consistency (Choo et al. 1999: 527-541). Conceptually, weighting methods can be studied in two main categories: objective weighting methods and subjective weighting methods. The objective methods obtain criteria weights via applying mathematical techniques without any external influence (Zardari et al. 2014). This is an important advantage for the decision-maker in order to employ a neutral evaluation.

3.2.2.Entropy Method

Entropy is a handy concept in information theory, where it is relevant to measuring the amount of the expected information content of a certain message (H wang and Yoon 1981). It indicates that a large deviation represents more uncertainty than does a sharply peaked one (Deng et al. 2000: 963-973). To calculate the weights by entropy method, first the information matrix is normalized, then the following equations are used.

The entropy method consists of the following steps (Hwang and Yoon 1981; Islamoglu et al. 2015: 124-138):

Equation (1) shows the decision matrix *D* of a multi-criteria problem with *m* alternatives and *n* criteria,

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} X_1 & X_2 & \cdots & X_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \end{array} \quad \textbf{(1)}$$

where x_{ij} is the achievement value of the *i*th alternative for the *j*th criterion.

Step 1: $R = [r_{ij}]_{m\times n}$ normalized decision matrix calculated by the following formula:

$$r_{ij} = \frac{x_{ij}}{\sum_{p=1}^{m} x_{pj}} \quad ,i = 1,2, \dots , m \,, j = 1,2, \dots , n \quad \textbf{(2)}$$

The aim of the normalization is to obtain same scale for all criteria and so to make comparison between them.

Step 2: $e_j = -K \sum_{i=1}^{m} r_{ij} \ln r_{ij} \,, \; j = 1,2, \dots , n \,.$ **(3)**

The entropy value e_j for the *j*th criterion is obtained via the above formula, where *K* is a constant number: $K = \frac{1}{\ln m}$, which assurances that $0 \leq e_j \leq 1$.

Step 3: The degree of diversification d_j of the average information contained by the outcomes of criterion *j* can be obtained as

$$d_j = 1 - e_j \quad , \; j = 1,2, \dots , n \quad \textbf{(4)}$$

Step 4: Finally, the weight of *j*th criterion can be defined as

$$W_j = \frac{1 - e_j}{\sum_{p=1}^{n} (1 - e_p)} \,, \; j = 1,2, \dots , n \,. \quad \textbf{(5)}$$

as addition $\sum_{j=1}^{n} W_j = 1$ is clear.

3.2.3. MAUT Method

The main hypothesis of the MAUT method is that there is a real valued utility function *U* so that the decision-maker's desire is maximized (deliberately or not) (Olson 1995). This function aggregates all criteria. The task of the decision-maker is to accurately define or select the function. The selection process can be seen in (De Montis et al. 2005: 1-12; Keeney 1977: 267-310; Keeney and Raiffa 1993). As in most studies in this paper, we have used the additive utility function.

Each alternative gives an output that has values in different dimensions. The MAUT method searches to measure these values, one dimension at a time, via a weighting procedure (Zietsman et al. 2006).

The MAUT method can be explained by the following steps (Erol et al. 2011: 1088-1100; Zietsman et al. 2006: 254-266):

Step 1: The normalized utilities values r_{ij} are calculated by the following formulas, respectively, for benefit criteria and cost criteria:

$$r_{ij} = \frac{x_{ij}-l_j^-}{u_j^+-l_j^-} \quad in\ here\ \ u_j^+ = \max_i x_{ij}\ \ ve\ l_j^- = \min_i x_{ij} \tag{6}$$

$$r_{ij} = \frac{u_j^+-x_{ij}}{u_j^+-l_j^-} \quad in\ here\ \ u_j^+ = \max_i x_{ij}\ \ ve\ l_j^- = \min_i x_{ij} \tag{7}$$

Step 2: Sum of the weighted values of r_{ij} give the total utility values for each alternative:

$$U_i = \sum_{j=1}^{n} w_j\, r_{ij} \tag{8}$$

Step 3: Preference ranking is done. The alternative with the highest total utility value would be the best alternative.

4. Results of Analysis

4.1.DEA Application for the Determination of Financial Performance Efficiency

In this section, CCR and BCC models of DEA for computing relative technical efficiency of textile firms were used. The inputs and outputs of models were chosen in the above-stated forms. Firms (DMUs) are split into two groups by DEA, which are the efficient and inefficient firms. Efficient firms receive a 1/100% efficiency score. Inefficient firms receive a greater than 1/100% efficiency score. Generally, a [0,100] range is used in effectiveness evaluation; for this reason in this study, reverse / opposite of these efficiency scores were used in CCR and BCC model results. Efficiency calculations were performed using efficiency measurement system (EMS) software from Dortmund University. Relative technical efficient scores of firms of CCR and BCC models (2008–2015 years) are presented in Table 2.

Table 2: CCR and BCC Technical Efficiency Scores (%) of Firms (2008–2015)

Years	**2008**		**2009**		**2010**		**2011**		**2012**		**2013**		**2014**		**2015**	
Firms	CCR	BCC	CCR	BCC	CCR	BCC	CCR	BCC	CCR	BCC	CCR	BCC	CCR	BCC	CCR	BCC
ATEKS	57	66	99	100	89	100	100	100	100	100	100	100	100	100	100	100
ARSAN	57	70	90	93	24	100	100	100	100	100	100	100	100	100	100	100
BLCYT	100	100	100	100	100	100	90	91	100	100	95	95	94	98	93	96
BRKO	52	64	76	79	65	82	77	92	98	98	72	72	92	96	81	84
BRMEN	47	65	100	100	70	100	85	100	100	100	57	58	69	75	100	100
BISAS	100	100	100	100	48	100	100	100	100	100	100	100	100	100	100	100
BOSSA	100	100	82	85	79	83	100	100	99	100	89	89	95	96	100	100
DAGI	52	56	100	100	100	100	100	100	74	100	71	74	84	85	83	86
DERIM	45	48	65	65	59	99	100	100	100	100	100	100	100	100	100	100
DESA	100	100	100	100	94	100	100	100	100	100	100	100	100	100	100	100
ESEMS	43	77	100	100	100	100	100	100	100	100	100	100	100	100	81	84
HATEK	72	80	100	100	100	100	100	100	92	99	93	96	79	82	92	96
IDAS	39	60	100	100	22	90	59	77	24	100	100	100	100	100	100	100
KRTEK	51	57	58	60	71	94	75	75	79	80	65	65	74	75	82	84
KORDS	58	60	84	85	92	97	100	100	100	100	100	100	100	100	100	100
LUKSK	50	57	71	73	86	96	100	100	100	100	70	70	80	81	82	85
MNDRS	75	82	100	100	100	100	100	100	100	100	100	100	92	93	96	97
MEMSA	33	72	98	100	100	100	100	100	100	100	100	100	100	100	100	100
SKTAS	53	54	75	76	74	87	100	100	100	100	100	100	100	100	100	100
SNPAM	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
YATAS	50	55	79	79	58	78	65	69	66	67	83	83	84	85	100	100
YUNSA	57	66	82	82	74	87	88	100	88	100	89	100	100	100	87	89

In these tables, firms with 100% efficiency scores are efficient firms. Firms that have less than 100% efficiency scores are considered inefficient firms. An inefficient firmbecome an efficient firm when output expands with a 100% efficiency score. Thirteen firms in 2015, according to Table 2, are efficient and others are inefficient. Efficiency scores perthe CCR model are less than or equal to those of the BCC model. The CCR model computes global (overall) efficiency values, whereas the BCC model gives local (weak, pure) efficient values.

Box plots are available for comparison with other interpretations of variability of performance scores of firms (CCR and BCC models) between the years 2008–2015. A box plot contains information about the distribution of a variable. For example, quartiles, approximate mean, range, skewness of distribution variable, homogeneity, or heterogeneity. Also in regards to outliers and extremum (represented by circles and stars in charts, respectively), the box plot of relative technical efficient scores of firms of CCR and BCC models (2008–2015 years) are shown in Figures 2 and 3, respectively.

Figure 2: Box plot of CCR technical efficiency scores of firms (2008–2015)

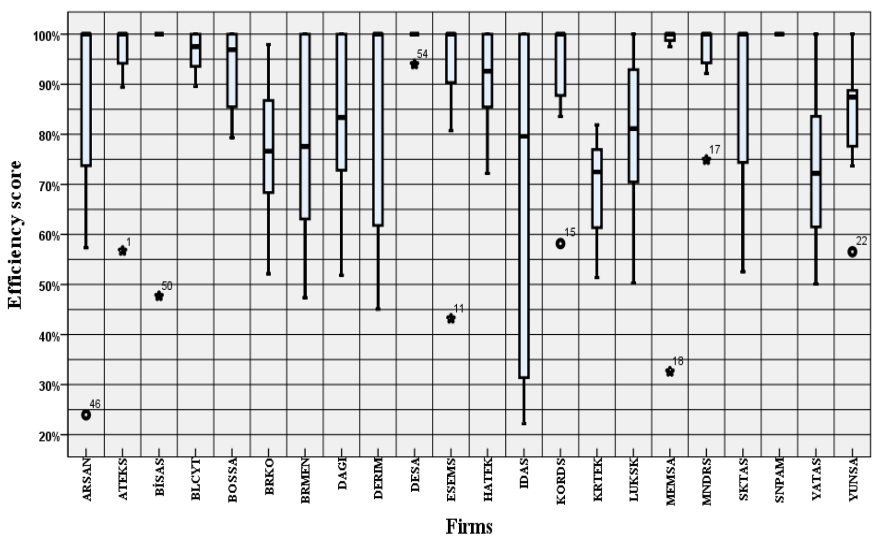
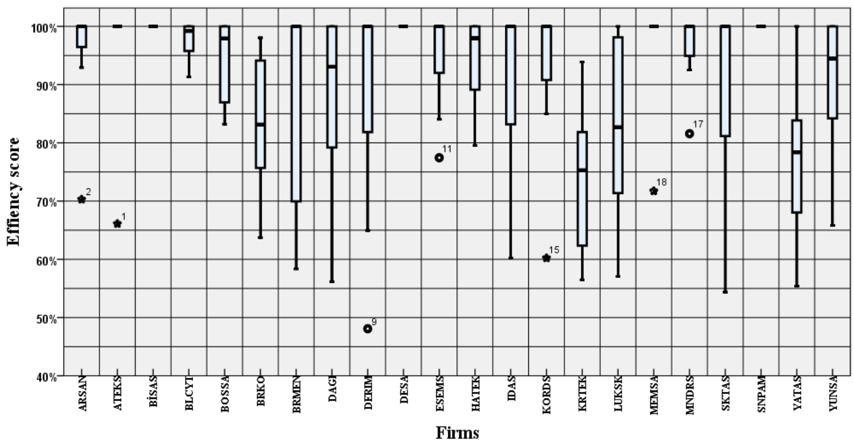


Figure 3: Box plot of BCC technical efficiency scores of firms (2008–2015)



According to Figure 2, SNPAM has remained efficient all these years, and there is no variability. This is a desired situation and is ideal in practise. In one case, DESA and BISAS firms are in a good position. Performance scores of IDAS, BISAS, and BRMEN firms are more variable than others; thus, distribution of their performance scores is inhomogeneous.

According to Figure 3, SNPAM, DESA, BISAS, MEMSA, and ATEKS firms are in good positions. Performance scores of YATAS, LUKSK, DAGI, SKTAS, and ERMEN firms are more variable than others; thus, distribution of their performance scores is inhomogeneous. The distribution of performance scores of BCC model is more homogeneous than distribution of the performance scores of CCR model.

DEA gives a single score to all efficient DMUs: 100% efficiency score. Efficient DMUs also can be ranked with the super-efficiency concept.

Efficient DMUs are sorted by Andersen and Petersen's super-efficiency model, while performance scores of inefficient DMUs remain unchanged. Super-efficiency scores of efficient firms obtained via Andersen and Petersen's new models are shown in Table 3.

Table 3: BCC (VRS) and CCR (CRS) Scores with Super-Efficiency

Years	2008		2009		2010		2011		2012		2013		2014		2015	
Firms	**BCC**	**CCR**	**BCC**	**CCR**	**BCC**	**CCR**	**BCC**	**CCR**	**BCC**	**CCR**	**BCC**	**CCR**	**BCC**	**CCR**	**BCC**	**CCR**
ATEKS	0.661	0.567	1.002	0.989	1.355	0.894	1.106	1.077	1.464	1.436	1.672	1.631	15.950	2.547	20.919	2.497
ARSAN	0.703	0.573	0.929	0.901	1.105	0.240	2.104	2.102	2.199	1.301	3.382	1.269	1.425	1.334	1.155	1.134
BLCYT	4.470	17.127	16.948	12.710	3.522	2.688	0.913	0.896	1.021	1.008	0.952	0.950	0.984	0.941	0.964	0.931
BRKO	0.638	0.521	0.794	0.762	0.822	0.650	0.921	0.770	0.980	0.979	0.720	0.717	0.962	0.924	0.841	0.811
BRMEN	0.651	0.474	1.198	1.195	1.168	0.697	1.242	0.854	1.369	1.213	0.584	0.573	0.748	0.688	1.233	1.104
BISAS	4.480	3.416	16.959	2.917	4.289	0.477	2.110	13.304	2.408	2.072	3.390	2.210	2.846	2.816	20.920	5.266
BOSSA	1.178	1.178	0.848	0.819	0.832	0.793	1.009	1.000	1.241	0.991	0.891	0.891	0.959	0.947	1.225	1.204
DAGI	0.562	0.519	1.147	1.147	1.558	1.460	1.107	1.105	3.919	0.743	0.737	0.713	0.847	0.840	0.862	0.827
DERIM	0.481	0.451	0.650	0.649	0.988	0.587	1.750	1.714	3.627	1.216	1.170	1.164	2.762	2.462	4.263	4.256
DESA	1.143	1.032	1.499	1.426	1.472	0.940	2.078	1.910	2.279	2.130	2.584	2.549	3.104	3.087	3.762	3.710
ESEMS	0.774	0.432	1.355	1.331	4.290	37.761	2.105	13.848	32.800	3.985	2.105	2.079	1.318	1.291	0.840	0.807
HATEK	0.795	0.722	1.570	1.561	1.186	1.111	1.095	1.069	0.995	0.919	0.965	0.931	0.821	0.791	0.961	0.922
IDAS	0.603	0.392	16.958	1.090	0.896	0.222	0.767	0.592	1.083	0.236	2.049	2.044	1.682	1.609	20.920	10.607
KRTEK	0.565	0.514	0.596	0.582	0.939	0.710	0.752	0.749	0.796	0.790	0.651	0.645	0.753	0.740	0.841	0.819
KORDS	0.602	0.582	0.850	0.836	0.966	0.920	1.015	1.009	1.200	1.085	1.018	1.016	15.943	14.732	20.914	3.377
LUKSK	0.571	0.503	0.729	0.712	0.963	0.859	1.139	1.115	1.963	1.021	0.699	0.698	0.805	0.800	0.848	0.823
MNDRS	0.816	0.749	1.094	1.036	1.104	1.073	1.744	1.368	1.164	1.118	1.483	1.239	0.925	0.922	0.974	0.963
MEMSA	0.717	0.326	1.133	0.975	2.601	1.830	1.289	1.008	1.246	1.236	4.420	3.927	7.943	7.263	17.696	12.947
SKTAS	0.544	0.526	0.755	0.752	0.868	0.736	1.083	1.080	1.196	1.019	1.308	1.280	1.333	1.308	1.541	1.531
SNPAM	4.465	3.478	16.957	10.127	3.051	2.114	1.509	1.090	2.085	1.523	4.439	8.000	3.564	3.342	3.533	3.482
YATAS	0.554	0.501	0.789	0.789	0.779	0.582	0.688	0.648	0.673	0.656	0.831	0.830	0.846	0.842	1.131	1.041
YUNSA	0.658	0.565	0.816	0.816	0.868	0.737	1.471	0.883	32.794	0.884	4.438	0.891	1.273	1.106	0.890	0.866

4.2.MAUT Application and Ranking

4.2.1.Entropy Weighting

When we analyze the weights according to the years calculated by the entropy method given in the Table 4, it is observed that they generally value at similar levels. Criteria 3 and 5 appear to have the lowest weights in all periods. In this criteria, the alternatives have relatively close values to each other and the weight values are kept at lower levels. In Criteria 8, 6, and 2, the entropy method assigns high values to these criteria because variability is high among alternatives. Differences in data relative to years also have led to differences in weights. This gives sensitivity to the evaluation of alternatives. According to the changes in the financial environment, it is expected that the criteria will change between the levels of importance. For example, the fifth criterion is the lowest weighted criterion in 2011, and the highest weighted criterion in 2013.

Table 4: Weights Calculated by Entropy Method (2008–2015)

Criteria	**Current Ratio**	**Acid-Test Ratio**	**Financial Leverage Ratio**	**Receivable turnover in days**	**Inventory turnover in days**	**Net Profit Margin**	**Return on Assets**	**Return on Equity**
Years	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
2008	0.199	0.212	0.043	0.079	0.079	0.148	0.086	0.154
2009	0.183	0.201	0.036	0.081	0.078	0.168	0.113	0.141
2010	0.062	0.087	0.024	0.186	0.027	0.116	0.104	0.394
2011	0.141	0.193	0.038	0.045	0.033	0.195	0.196	0.161
2012	0.195	0.256	0.026	0.065	0.041	0.145	0.119	0.153
2013	0.086	0.125	0.018	0.217	0.241	0.161	0.073	0.078
2014	0.071	0.109	0.022	0.173	0.043	0.262	0.126	0.195
2015	0.088	0.129	0.028	0.309	0.033	0.176	0.110	0.126

Table 5: MAUT Multi-Utility Function Values

Years Firms	2008	2009	2010	2011	2012	2013	2014	2015
ATEKS	0.638	0.820	0.936	0.783	0.784	0.974	0.892	0.958
ARSAN	0.669	0.766	0.925	0.701	0.727	0.963	0.815	0.928
BLCYT	0.967	0.968	0.950	0.574	0.719	0.963	0.830	0.940
BRKO	0.782	0.777	0.900	0.694	0.726	0.944	0.837	0.909
BRMEN	0.529	0.770	0.906	0.765	0.717	0.946	0.776	0.884
BISAS	0.909	0.881	0.960	0.830	0.901	0.983	0.948	0.983
BOSSA	0.615	0.774	0.918	0.640	0.769	0.957	0.865	0.953
DAGI	0.771	0.890	0.946	0.640	0.618	0.912	0.855	0.948
DERIM	0.561	0.789	0.921	0.689	0.771	0.957	0.833	0.934
DESA	0.382	0.494	0.868	0.532	0.595	0.926	0.766	0.902
ESEMS	0.847	0.904	0.979	0.944	0.986	0.993	0.942	0.953
HATEK	0.824	0.893	0.912	0.771	0.777	0.968	0.873	0.952
IDAS	0.419	0.782	0.850	0.433	0.658	0.943	0.633	0.908
KRTEK	0.540	0.820	0.924	0.657	0.776	0.949	0.839	0.948
KORDS	0.710	0.842	0.941	0.752	0.799	0.968	0.913	0.968
LUKSK	0.484	0.764	0.900	0.649	0.704	0.949	0.823	0.924
MNDRS	0.693	0.853	0.945	0.735	0.794	0.965	0.880	0.954
MEMSA	0.275	0.019	0.046	0.365	0.316	0.000	0.189	0.014
SKTAS	0.637	0.801	0.931	0.723	0.767	0.963	0.879	0.954
SNPAM	0.754	0.665	0.927	0.671	0.738	0.961	0.894	0.949
YATAS	0.435	0.753	0.887	0.508	0.528	0.933	0.796	0.928
YUNSA	0.530	0.753	0.904	0.617	0.724	0.948	0.827	0.918

Table 5 lists the MAUT multi-utility function values of firms. Table 8 also lists the financial performance analysis rankings of companies according to the MAUT method in 2008–2015. It is seen that BISAS and ESEMS firms have received the first two orders with close performance. KORDS and ATEKS firms steadily increased their financial performances and obtained third and fourth orders. YATAS, IDAS, DESA, and MEMSA were in the last place with poor performances in all periods. MNDRS, HATEK, and SKTAS companies achieved a moderately stable performance. BLCYT and DAGI have attracted attention with their falling performances. The performances of other firms followed a low level of performance.

4.2.2.The Correlation Results of MAUT Method and CRR and BCC Models of DEA

Correlation is one of the easiest ways to compare models. High correlation reveals the similarity of the results obtained by the models. For this purpose, correlations of model rankings were calculated first.

Over the years, the correlation between the rankings assigned by the models for each alternative has been investigated. Since the ranking values of the alternatives were examined, Spearman's correlation was chosen as the most appropriate method.Table 6 shows correlations between CCR and MAUT models. In the table, correlations between all years are given, while the portion we will consider is correlated between CCR and MAUT for the same year. The same is true for Table 7. In Table 7, BCC and MAUT correlations are given. The correlation between the results of MAUT method and CCR and BCC models of DEA are low. Tables 6 and 7 shows these results. In Table 6 only 2008 and 2011 and in Table 7 2010 year’s results are significantly correlated.

Table 8 summarizes the rankings of the models for all years. In the table, the order of success that models have determined for each alternative over the years is seen. The similarities or differences between the results of the models can also be seen in this table. We aimed to evaluate all three methods together with Table 8 analysis. Thus, we aimed to achieve general results. In this context, it was determined that BISAS is the best firm for all three methods for the period of 2008–2015 when ranking according to general average. This is followed by ESEMS, SNPAM, ATEKS, KORDS.

5. Conclusion

In this study, the efficiency and performance evaluation of the 2008–2015 period was made using the data of BIST textile firms. In this context, DEA BCC, CCR, and MAUT methods have been applied for empirical analysis of BİST Textile sector firms’ data for the 2008–2015 period. According to the empirical analysis results, according to the method of DEA (BCC), 12 firms in the year 2008, 12 in the year 2009, 12 in the year 2010, 17 in the year 2011, 18 in the year 2012, 13 in the year 2013, 12 in the year 2014, and 13 in the year 2015 were efficient. On the other hand, it was determined that BISAS, DESA, and SNPAM firms were efficient in the 2008–2015 period. Companies that were efficient in the last five years have been identified as ATEKS, ARSAN, BISAS, DERIM, KORDS, MEMSA, SKTAS, and SNPAM. Moreover, according to the method of DEA (CCR), it was determined that five firms were active in 2008, 10 in 2009, seven in 2010, 14 in 2011, 14 in 2012, 12 in 2013, 12 in 2014, and 13 in 2015. It is determined that only a SNPAM company remained efficient in this frame in the 2008–2015 period. On the other hand, companies that have been active in the last five years have been identified as ATEKS, ARSAN, BISAS, DERIM, KORDS, MEMSA, SKTAS, SNPAM. According to the analysis made by the

MAUT method, ESEMS firm showed the highest performance in the whole period; further, it was determined that it followed BISAS, HATEK, BLCYT, and KORDS firms.

In this study, the efficiency and performance orders obtained with the DEA (BCC), DEA (CCR), and MAUT methods were examined together and then compared. Accordingly, it was seen that BISAS was the most successful company during the whole period for the three methods. The following companies were found to be ESEMS, SNPAM, ATEKS, and KORDS.

In line with the purpose of the study, the financial outlook of firms in the textile sector has been tried to be demonstrated by different MCDM methods. In this way, sectoral stakeholders and investors have been provided with tools to evaluate. The preference rankings obtained by different MCDM methods are compared and the differences of the results reached are illustrated. The determination of the most appropriate method is beyond the scope of this study.

In subsequent studies, the findings will vary widely, as the input and output variables differ. For this reason, the studies to be done with different input and output variables can be evaluated by comparing with this study.

In this study, the efficiency and performance measurement methods were compared with each other and evaluated. In the efficiency and performance measurement studies, an evaluation can be made by comparing the results obtained in this study, using different sectors and criteria. For this reason, it is expected that the results obtained in this study will provide guidance for new efficiency and performance analysis. In this framework, different activities can be done that can be used together with other efficiency or performance measurement methods.

Table 6: Correlation of CCR Ranks and MAUT Ranks with Sperman Tests

	2008 CCR	2009 CCR	2010 CCR	2011 CCR	2012 CCR	2013 CCR	2014 CCR	2015 CCR	2008 M	2009 M	2010 M	2011 M	2012 M	2013 M	2014 M	2015 M
2008	1	0.456*	0.246	0.243	0.213	0.182	0.170	0.072	0.514*	0.195	0.422	0.184	0.319	0.420	0.448*	0.493*
CCR	.	0.033	0.271	0.275	0.342	0.417	0.450	0.751	0.014	0.385	0.051	0.414	0.148	0.052	0.037	0.020
2009	0.456*	1	0.470*	0.264	0.371	0.455*	0.189	0.193	0.441*	0.285	0.335	0.160	0.055	0.241	0.190	0.124
CCR	0.033	.	0.027	0.236	0.089	0.034	0.399	0.391	0.040	0.198	0.128	0.477	0.809	0.280	0.396	0.584
2010	0.246	0.470*	1	0.254	0.269	0.223	0.075	-0.214	0.324	0.246	0.330	0.024	0.077	0.170	0.296	0.191
CCR	0.271	0.027	.	0.255	0.225	0.318	0.740	0.339	0.142	0.271	0.133	0.915	0.732	0.450	0.180	0.393
2011	0.243	0.264	0.254	1	0.745**	0.471*	0.331	0.104	0.335	0.194	0.491*	0.452*	0.389	0.469*	0.414	0.364
CCR	0.275	0.236	0.255	.	0.000	0.027	0.132	0.644	0.128	0.388	0.020	0.035	0.074	0.028	0.056	0.096
2012	0.213	0.371	0.269	0.745**	1	0.642**	0.561**	0.340	0.161	-0.074	0.310	0.460*	0.344	0.426*	0.295	0.177
CCR	0.342	0.089	0.225	0.000	.	0.001	0.007	0.121	0.474	0.744	0.160	0.031	0.117	0.048	0.182	0.431
2013	0.182	0.455*	0.223	0.471*	0.642**	1	0.836**	0.657**	0.049	-0.107	0.123	0.049	0.155	0.266	0.187	0.162
CCR	0.417	0.034	0.318	0.027	0.001	.	0.000	0.001	0.828	0.636	0.587	0.828	0.490	0.232	0.405	0.471
2014	0.170	0.189	0.075	0.331	0.561**	0.836**	1	0.755**	-0.045	-0.229	0.055	-0.037	0.118	0.151	0.154	0.147
CCR	0.450	0.399	0.740	0.132	0.007	0.000	.	0.000	0.844	0.306	0.809	0.871	0.601	0.503	0.493	0.513
2015	0.072	0.193	-0.214	0.104	0.340	0.657**	0.755**	1	-0.336	-0.326	-0.199	-0.174	-0.107	-0.062	-0.143	-0.011
CCR	0.751	0.391	0.339	0.644	0.121	0.001	0.000	.	0.126	0.139	0.374	0.437	0.636	0.786	0.526	0.962
2008	0.514*	0.441*	0.324	0.335	0.161	0.049	-0.045	-0.336	1	0.759**	0.809**	0.596**	0.617**	0.671**	0.746**	0.630**
M	0.014	0.040	0.142	0.128	0.474	0.828	0.844	0.126	.	0.000	0.000	0.003	0.002	0.001	0.000	0.002
2009	0.195	0.285	0.246	0.194	-0.074	-0.107	-0.229	-0.326	0.759**	1	0.770**	0.543**	0.626**	0.636**	0.616**	0.642**
M	0.385	0.198	0.271	0.388	0.744	0.636	0.306	0.139	0.000	.	0.000	0.009	0.002	0.001	0.002	0.001
2010	0.422	0.335	0.330	0.491*	0.310	0.123	0.055	-0.199	0.809**	0.770**	1	0.618**	0.694**	0.728**	0.804**	0.787**
M	0.051	0.128	0.133	0.020	0.160	0.587	0.809	0.374	0.000	0.000	.	0.002	0.000	0.000	0.000	0.000
2011	0.184	0.160	0.024	0.452*	0.460*	0.049	-0.037	-0.174	0.596**	0.543**	0.618**	1	0.832**	0.815**	0.735**	0.628**
M	0.414	0.477	0.915	0.035	0.031	0.828	0.871	0.437	0.003	0.009	0.002	.	0.000	0.000	0.000	0.002
2012	0.319	0.055	0.077	0.389	0.344	0.155	0.118	-0.107	0.617**	0.626**	0.694**	0.832**	1	0.892**	0.861**	0.811**
M	0.148	0.809	0.732	0.074	0.117	0.490	0.601	0.636	0.002	0.002	0.000	0.000	.	0.000	0.000	0.000
2013	0.420	0.241	0.170	0.469*	0.426*	0.266	0.151	-0.062	0.671**	0.636**	0.728**	0.815**	0.892**	1	0.798**	0.798**
M	0.052	0.280	0.450	0.028	0.048	0.232	0.503	0.786	0.001	0.001	0.000	0.000	0.000	.	0.000	0.000
2014	0.448*	0.190	0.296	0.414	0.295	0.187	0.154	-0.143	0.746**	0.616**	0.804**	0.735**	0.861**	0.798**	1	0.919**
M	0.037	0.396	0.180	0.056	0.182	0.405	0.493	0.526	0.000	0.002	0.000	0.000	0.000	0.000	.	0.000
2015	0.493*	0.124	0.191	0.364	0.177	0.162	0.147	-0.011	0.630**	0.642**	0.787**	0.628**	0.811**	0.798**	0.919**	1
M	0.020	0.584	0.393	0.096	0.431	0.471	0.513	0.962	0.002	0.001	0.000	0.002	0.000	0.000	0.000	.

*Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed), **M**:MAUT, **CCR**: Charnes Cooper Rhodes Model

Table 7: Correlation of BCC Ranks and MAUT Ranks with Sperman Tests

	2008 M	**2009 M**	**2010 M**	**2011 M**	**2012 M**	**2013 M**	**2014 M**	**2015 M**	**2008 BCC**	**2009 BCC**	**2010 BCC**	**2011 BCC**	**2012 BCC**	**2013 BCC**	**2014 BCC**	**2015 BCC**
2008	1.000	0.759**	0.809**	0.596**	0.617**	0.671**	0.746**	0.630**	0.382	0.336	0.430*	0.137	0.064	0.008	0.014	-0.248
M		0.000	0.000	0.003	0.002	0.001	0.000	0.002	0.079	0.126	0.046	0.543	0.778	0.970	0.950	0.266
2009	0.759**	1.000	0.770**	0.543**	0.626**	0.636**	0.616**	0.642**	0.092	0.229	0.330	-0.073	-0.066	-0.231	-0.141	-0.189
M	0.000		0.000	0.009	0.002	0.001	0.002	0.001	0.684	0.306	0.133	0.747	0.770	0.301	0.533	0.399
2010	0.809**	0.770**	1.000	0.618**	0.694**	0.728**	0.804**	0.787**	0.244	0.212	0.500*	0.266	0.266	0.069	0.110	-0.080
M	0.000	0.000		0.002	0.000	0.000	0.000	0.000	0.273	0.344	0.018	0.232	0.232	0.759	0.626	0.725
2011	0.596**	0.543**	0.618**	1.000	0.832**	0.815**	0.735**	0.628**	0.141	0.088	0.281	0.372	0.177	-0.015	0.033	-0.006
M	0.003	0.009	0.002		0.000	0.000	0.000	0.002	0.533	0.699	0.206	0.088	0.431	0.946	0.883	0.978
2012	0.617**	0.626**	0.694**	0.832**	1.000	0.892**	0.861**	0.811**	0.222	0.011	0.184	0.254	0.097	0.116	0.159	0.025
M	0.002	0.002	0.000	0.000		0.000	0.000	0.000	0.321	0.962	0.414	0.255	0.669	0.608	0.481	0.911
2013	0.671**	0.636**	0.728**	0.815**	0.892**	1.000	0.798**	0.798**	0.335	0.165	0.328	0.282	0.106	0.203	0.207	0.080
M	0.001	0.001	0.000	0.000	0.000		0.000	0.000	0.128	0.462	0.136	0.204	0.640	0.366	0.355	0.725
2014	0.746**	0.616**	0.804**	0.735**	0.861**	0.798**	1.000	0.919**	0.237	0.110	0.278	0.194	0.153	0.121	0.191	-0.014
M	0.000	0.002	0.000	0.000	0.000	0.000		0.000	0.289	0.626	0.210	0.388	0.497	0.590	0.393	0.950
2015	0.630**	0.642**	0.787**	0.628**	0.811**	0.798**	0.919**	1.000	0.181	0.050	0.176	0.060	0.022	0.073	0.185	0.134
M	0.002	0.001	0.000	0.002	0.000	0.000	0.000		0.420	0.824	0.434	0.789	0.923	0.747	0.411	0.553
2008	0.382	0.092	0.244	0.141	0.222	0.335	0.237	0.181	1.000	0.704**	0.569**	0.378	0.135	0.464*	0.234	0.138
BCC	0.079	0.684	0.273	0.533	0.321	0.128	0.289	0.420		0.000	0.006	0.083	0.549	0.030	0.294	0.539
2009	0.336	0.229	0.212	0.088	0.011	0.165	0.110	0.050	0.704**	1.000	0.700**	0.290	0.176	0.435*	0.281	0.333
BCC	0.126	0.306	0.344	0.699	0.962	0.462	0.626	0.824	0.000		0.000	0.191	0.434	0.043	0.206	0.130
2010	0.430*	0.330	0.500*	0.281	0.184	0.328	0.278	0.176	0.569**	0.700**	1.000	0.580**	0.471*	0.397	0.338	0.165
BCC	0.046	0.133	0.018	0.206	0.414	0.136	0.210	0.434	0.006	0.000		0.005	0.027	0.067	0.124	0.462
2011	0.137	-0.073	0.266	0.372	0.254	0.282	0.194	0.060	0.378	0.290	0.580**	1.000	0.809**	0.602**	0.343	0.151
BCC	0.543	0.747	0.232	0.088	0.255	0.204	0.388	0.789	0.083	0.191	0.005		0.000	0.003	0.118	0.503
2012	0.064	-0.066	0.266	0.177	0.097	0.106	0.153	0.022	0.135	0.176	0.471*	0.809**	1.000	0.488*	0.344	0.093
BCC	0.778	0.770	0.232	0.431	0.669	0.640	0.497	0.923	0.549	0.434	0.027	0.000		0.021	0.117	0.680
2013	0.008	-0.231	0.069	-0.015	0.116	0.203	0.121	0.073	0.464*	0.435*	0.397	0.602**	0.488*	1.000	0.746**	0.455*
BCC	0.970	0.301	0.759	0.946	0.608	0.366	0.590	0.747	0.030	0.043	0.067	0.003	0.021		0.000	0.034
2014	0.014	-0.141	0.110	0.033	0.159	0.207	0.191	0.185	0.234	0.281	0.338	0.343	0.344	0.746**	1.000	0.715**
BCC	0.950	0.533	0.626	0.883	0.481	0.355	0.393	0.411	0.294	0.206	0.124	0.118	0.117	0.000		0.000
2015	-0.248	-0.189	-0.080	-0.006	0.025	0.080	-0.014	0.134	0.138	0.333	0.165	0.151	0.093	0.455*	0.715**	1.000
BCC	0.266	0.399	0.725	0.978	0.911	0.725	0.950	0.553	0.539	0.130	0.462	0.503	0.680	0.034	0.000	

*Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed), **BCC**: Banker Charnes Cooper Model

Table 8: Comparative DEA (BCC, CCR) and MAUT Rankings (2008–2015)

Year	**2008**			**2009**			**2010**			**2011**			**2012**			**2013**			**2014**			**2015**		
Firms	**B**	**C**	**M**	**B**	**C**	**M**	**B**	**C**	**M**	**B**	**C**	**M**	**B**	**C**	**M**	**B**	**C**	**M**	**B**	**C**	**M**	**B**	**C**	**M**
ATEKS	11	10	11	12	11	8	8	10	7	13	11	3	10	5	5	9	7	3	1	6	5	3	8	3
ARSAN	10	9	10	13	13	16	11	21	10	3	3	9	7	6	12	5	9	9	9	9	17	12	11	15
BLCYT	2	1	1	4	1	1	3	2	3	19	16	18	18	14	15	15	13	8	13	14	14	15	15	12
BRKO	14	13	5	17	18	13	21	17	17	18	19	10	20	16	13	19	18	17	14	15	12	21	21	18
BRMEN	13	18	17	8	7	15	10	16	15	10	18	5	11	9	16	22	22	16	22	22	19	10	12	21
BISAS	1	3	2	1	3	5	2	20	2	1	2	2	5	3	2	4	4	2	6	5	1	1	3	1
BOSSA	4	4	13	15	15	14	20	12	13	17	15	15	13	15	9	16	16	12	15	13	9	11	10	6
DAGI	19	14	6	9	8	4	6	5	4	12	8	16	3	20	19	18	19	21	17	18	10	18	18	10
DERIM	22	19	14	21	21	11	13	18	12	5	5	11	4	8	8	12	11	11	7	7	13	6	4	13
DESA	5	5	21	6	5	21	7	8	20	4	4	19	6	2	20	6	3	20	5	4	20	7	5	20
ESEMS	8	20	3	7	6	2	1	1	1	2	1	1	1	1	1	7	5	1	11	11	2	22	22	7
HATEK	7	7	4	5	4	3	9	6	14	14	12	4	19	17	6	14	14	4	19	20	8	16	16	8
IDAS	15	21	20	2	9	12	17	22	21	20	22	21	17	22	18	8	6	18	8	8	21	2	2	19
KRTEK	18	15	15	22	22	9	16	15	11	21	20	13	21	19	7	21	21	14	21	21	11	20	20	11
KORDS	16	8	8	14	14	7	14	9	6	16	13	6	14	11	3	13	12	5	2	1	3	4	7	2
LUKSK	17	16	18	20	20	17	15	11	18	11	7	14	9	12	17	20	20	13	20	19	16	19	19	16
MNDRS	6	6	9	11	10	6	12	7	5	6	6	7	16	10	4	10	10	6	16	16	6	14	14	4
MEMSA	9	22	22	10	12	22	5	4	22	9	14	22	12	7	22	3	2	22	3	2	22	5	1	22
SKTAS	21	12	12	19	19	10	18	14	8	15	10	8	15	13	10	11	8	7	10	10	7	9	9	5
SNPAM	3	2	7	3	2	20	4	3	9	7	9	12	8	4	11	1	1	10	4	3	4	8	6	9
YATAS	20	17	19	18	17	19	22	19	19	22	21	20	22	21	21	17	17	19	18	17	18	13	13	14
YUNSA	12	11	16	16	16	18	19	13	16	8	17	17	2	18	14	2	15	15	12	12	15	17	17	17

B: BCC Model, **C**: CCR Model, **M**:MAUT

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