MEASURING FINANCIAL EFFICIENCY OF CEMENT FIRMS LISTED IN ISTANBUL STOCK EXCHANCE VIA FUZZY DATA ENVELOPMENT ANALYSIS

Zehra BAŞKAYA*
Burcu AVCI ÖZTÜRK**

ABSTRACT

Nowadays, businesses must use their resources efficiently because of heavy competition and uncertainty in market conditions. In order to determine whether a business is efficient or not, financial performance indicators have rather important place. To measure financial performance, financial ratio analysis is more commonly used. With the help of ratio analysis, information in businesses' financial statements are examined proportionally, and important indicators are reached about financial performance. Interpretation of this indicators for only one firm may not be enough. Therefore, financial ratios are subject to interfirm comparisons. In this study, cement firms', listed in Istanbul Stock Exchance (ISE), financial efficiency is evaluated via Fuzzy Data Envelopment Analysis (DEA). For this purpose, 15 cement firms' financial statements published between 2006-2010 are used. Minimum, average and maximum values of the financial ratios that calculated for businesses, are taken into consideration defined by triangular fuzzy numbers and relative efficiency scores are determined by Fuzzy DEA.

Keywords: *Financial efficiency measurement, cement firms' performance, Fuzzy DEA.*

JEL Classification*: M40, C61, C67.*

İstanbul Menkul Kıymetler Borsası'nda İşlem Gören Çimento Şirketlerinin Finansal Etkinliklerinin Bulanık Veri Zarflama Analizi İle Ölçümü

ÖZET

Günümüzde yaşanan yoğun rekabet ve piyasa koşullarındaki belirsizlikler nedeniyle işletmelerin kaynaklarını etkin bir şekilde kullanmaları gerekmektedir. İşletmelerin etkin olup olmadıklarının belirlenmesi açısından finansal performans göstergeleri oldukça önemli bir yere sahiptir. Finansal performansın ölçülmesi için finansal oran analizleri yaygın olarak kullanılmaktadır. Oran analizleri ile işletmelerin mali tablolarında yer alan bilgiler oransal olarak incelenerek finansal performansları hakkında önemli göstergelere ulaşılmaktadır. Bu göstergelerin bir işletme için yorumlanması tek başına yeterli olmayabilir. Bu nedenle, finansal oranlar işletmeler arası karşılaştırmalara konu olmaktadır. Yapılan çalışmada, İstanbul Menkul Kıymetler Borsası (İMKB)'nda işlem gören çimento şirketlerinin finansal performansları Bulanık Veri Zarflama Analizi (VZA) ile değerlendirilmiştir. Bu amaçla 15 çimento şirketinin 2006-2010 yılları arasında yayınlanmış olan finansal tabloları kullanılmıştır. Şirketler için hesaplanan finansal oranlar minimum, ortalama ve maksimum değerleri göz önüne alınarak üçgen bulanık sayılar ile ifade edilmiş ve göreli etkinlik değerleri Bulanık VZA ile belirlenmiştir..

Anahtar Kelimeler*: Finansal etkinlik ölçümü, çimento şirketlerinin performansı, Bulanık VZA*

JEL Sınıflandırması: *M40, C61, C67.*

* Doç. Dr. Zehra Başkaya, Uludağ Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, zbaskaya@uludag.edu.tr
** Arş.Gör. Dr. Burcu Avcı Öztürk, Uludağ Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, bavci@uludag.edu.tr

1. Introduction

In order to determine whether or not a business uses its resources efficiently, one of the most important indicator is businenesses' performance in the same sector. Interfirm comparisons are vitally important for measuring relative performance. When evaluating financial state of a business, the relationships between balance items in balance sheet and income statement should be taken into consideration. Therefore, decision makers utilize from ratios widely in financial analysis (Akgüç, 1998: 20). We define ratio as the mathematical relationship between any statement items.

Ratio analysis is in terms of only one input and one output, moreover ratios can be compared seperately. In evaluation of businesses' financial performance, one of the methods that is used for comparing Decision Making Units (DMUs), is Data Envelopment Analysis (DEA). DEA and ratio analysis when used together, they support each other substantially. Accepting some of the ratios as inputs and some of the ratios as outputs, we can do financial interfirm efficiency comparisons (Thanassolis et al., 1996: 229).

In content of this study, cement firms', listed in ISE, financial efficiencies measured via Fuzzy DEA. Yılmaz ve Çıracı (2004), Kavaklıdere ve Kargın (2004), Yıldız (2005), Yalama ve Sayım (2006), Kula ve Özdemir (2007), are examples to studies of performance in cement sector in Turkey. In all of these studies classical DEA models are used. Anayses are made by average values or for years seperately. The purpose of this study is to provide financial ratios' minimum and maximum values that are used between 2006-2010 in decision process.

First part of the study that measures the relative financial performance of cement firms, consists of a general introduction. In the second part, classical DEA and in the third part, Saati, Memariani and Jahanshahloo (2002)'s Fuzzy DEA model, that is used in the content of this study, are examined in detail. In the last part of the study, 15 cement firms' relative financial efficiencies have been measured via Fuzzy DEA.

2. Classical Data Envelopment Analysis (DEA)

DEA is a technique for the measurement of relative efficiency between DMUs. This technique is developed by Charnes, Cooper and Rhodes (1978) and first used in education sector (Carnes et al., 1978: 2469). DEA has provided measurement of relative efficiency between DMUs, using common inputs to produce common outputs.

DEA is a non-parametric and linear programming based technique. Basic elements of DEA are based on productivity. Ratio of total output to total input is used for the measurement of productivity. DEA has two models that are called input oriented model and output oriented model. This paperis focused on Charnes, Cooper and Rhodes (CCR) input oriented DEA model. DEA helps using many input and output variables in linear programming models and obtaining one efficiency score for each DMU (Gülcü, 2001: 121). In analysis with DEA, an efficiency score between 0 and 1 is calculated. DMUs which have efficiency score of “1” (%100) compose efficiency frontier. Input oriented CCR model is shown in (2.1) (Tarım, 2001: 13):

$$E_k = \sum_{r=1}^{s} u_{rk} Y_{rk} \quad \rightarrow \quad \text{maximum}$$

$$\sum_{i=1}^{m} v_{ik} X_{ik} = 1$$

$$\sum_{r=1}^{s} u_{rk} Y_{rj} - \sum_{i=1}^{m} v_{ij} X_{ij} \leq 0 \qquad j = 1,.....,n$$

$$u_{rk}, v_{ik} \geq \varepsilon \qquad r = 1,....,s \ ; \ i = 1,.....,m \tag{2.1}$$

m: quantity of the inputs of each DMU

s: output quantity of each DMU

n: quantity of DMU

Y_{rj}: r^{th} output of j^{th} DMU

X_{ij}: i^{th} input of j^{th} DMU

u_r: weight of r^{th} output

v_i: weight of i^{th} input

Although traditional DEA needs crisp data in analysis, the real evaluation of DMUs usually implies great uncertainty (Cooper et al, 1999: 597). In fact, as the system’s complexity increases, crisp evaluation of data becomes extremely difficult. Furthermore, decision makers use linguistic expressions such as quality is “good”, time performance is “low”, risk level is “high” (Dia, 2004:268). Fuzzy decision concept which developed by Bellman and Zadeh (1970) helps using uncertainty that comes from linguistic variables. In classical DEA models, weights that satisfy the constraints are selected to provide the highest efficiency scores for each DMU. When some observations are fuzzy, the objective function and constraints become fuzzy as well (Lotfi et al., 2007: 647). The DEA models with fuzzy data represent real-world problems more realistically than classical DEA models (Lertworasirikul et al., 2003, 339). For this reason, in order to evaluate the efficiency of

DMUs which have fuzzy input and output values, fuzzy numbers should be used in decision process (Wang et al., 2009: 5205).

3. Fuzzy Data Envelopment Analysis

In fuzzy environment, fuzzy DEA models are used for calculating efficiency scores of a homogeneous set DMUs (Azadeh et al., 2008: 1352). In order to evaluate the performance of DMUs, it's important to combine fuzzy modeling with classical DEA for sensivity and quality of data (Dia, 2004: 268). The fuzzy CCR model is formulated as the following linear programming model (Lotfi et al., 2007: 655):

$$\widetilde{E}_k = \sum_{r=1}^{s} u_r \widetilde{Y}_{rk} \qquad \rightarrow \quad \text{maximum}$$

$$\sum_{i=1}^{m} v_i \widetilde{X}_{ik} = 1$$

$$\sum_{r=1}^{s} u_r \widetilde{Y}_{rj} - \sum_{i=1}^{m} v_i \widetilde{X}_{ij} \leq 0$$

$$u_r , v_i \geq \varepsilon$$

(3.1)

Approaches that are used for solving fuzzy DEA models are categorized as tolerance approach, defuzziffication approach, α-cut level based approach and fuzzy ranking approach. Tolerance approach is developed by Sengupta (1992) and Kahraman and Tolga (1998). Sengupta (1992), had first expressed fuzziness of objective function and constraints. He applied fuzzy linear programming via fuzzification of objective function and constraints, so reached probabilistic efficiency frontier. In tolerance approach, aspiration level for objective function and tolerances for constraints are determined to express fuzziness. Defuzziffication approach developed by Lertworasirikul (2002). It is based on defuzziffication of fuzzy input and output values to crisp values. In α-cut level approach, DEA models are solved by parametric programming using α-cuts. α-cut based approaches are diversified by Kao ve Liu (2000), Lertworasirikul (2002), Saati, Memariani and Jahanshahloo (2002) and their studies. Despotis and Simirlis (2002), expressed calculating lower and upper efficiency scores without using α-cuts. Fuzzy ranking approach is developed by Guo and Tanaka (2001), and in this approach fuzzy equalities and inequalities are determined by fuzzy ranking methods.

Tolerance and fuzzy ranking approaches fuzzify objective function and constraints.In these approaches, fuzzy input and output values can not be directly integrated to the decision making problems. Defuzziffication approaches are easy to use but don't allow for treating the uncertainty of the inputs and the outputs. In α-cut level approaches, different α levels are determined by decision makers. They calculate efficiency scores and provide integration of fuzziness in decision process with intervals (Dia, 2004: 268).

In α-cut level based approaches input and output values must be expressed with fuzzy intervals. In solution of fuzzy linear programming problems, if coefficients are fuzzy decision makers prefer the approaches based on parametric programming. Thus, in this paper Saati, Memariani and Jahanshahloo (2002)'s fuzzy DEA model is used to solve the performance evaluation problem.

Saati, Memariani and Jahanshahloo (2002)'s fuzzy DEA model is applied for product processes' inputs and outputs defined as triangular fuzzy numbers. This model consists of two stages. In first stage α-cuts are found for fuzzy inputs and outputs; in the second stage, efficiency scores are calculated for each DMU. The triangular fuzzy numbers that are used for expressing fuzzy inputs and outputs are below (Karsak, 2008: 870):

$$\tilde{X}_{ij} = \left(X_{ij}^{L}, X_{ij}^{M}, X_{ij}^{U}\right) \quad 0 \le X_{ij}^{L} \le X_{ij}^{M} \le X_{ij}^{U} \tag{3.2}$$

$$\tilde{Y}_{rj} = \left(Y_{rj}^{L}, Y_{rj}^{M}, Y_{rj}^{U}\right) \quad 0 \le Y_{rj}^{L} \le Y_{rj}^{M} \le Y_{rj}^{U} \tag{3.3}$$

Let $S\left(\tilde{X}_{ij}\right)$ and $S\left(\tilde{Y}_{rj}\right)$ denote the support of $\tilde{X}_{ij}$ and $\tilde{Y}_{rj}$ respectively, α-cuts that represent fuzzy inputs' and outputs' membership functions should be formulated. α-cuts are crisp sets, those sets consist of the elements with membership values that are higher than α (Shian and Chuang, 2009: 1107).

α-cut intervals represent the lower and upper bounds of fuzzy inputs and outputs. Let $\left(X_{ij}\right)_{\alpha}^{L}$ and $\left(Y_{ij}\right)_{\alpha}^{L}$ denote the lower bounds, $\left(X_{ij}\right)_{\alpha}^{U}$ and $\left(Y_{ij}\right)_{\alpha}^{U}$ denote the upper bounds of α-cuts. The α-cuts' lower and upper bound intervals are expressed as follows (Shian and Chuang, 2009: 1107).

$$\left(X_{ij}\right)_{\alpha} = \left[\left(X_{ij}\right)^{L}, \left(X_{ij}\right)^{U}\right]$$

$$= \left[\min_{x_{ij}}\left\{x_{ij} \in X_{ij} \,\middle|\, \mu_{\tilde{X}_{ij}}\left(x_{ij}\right) \ge \alpha\right\}, \max_{x_{ij}}\left\{x_{ij} \in X_{ij} \,\middle|\, \mu_{\tilde{X}_{ij}}\left(x_{ij}\right) \ge \alpha\right\}\right] \tag{3.4}$$

$$\left(Y_{rj}\right)_{\alpha} = \left[\left(Y_{rj}\right)^{L}, \left(Y_{rj}\right)^{U}\right]$$

$$= \left[\underset{y_{rj}}{\text{Min}}\left\{y_{rj} \in Y_{rj} \,\middle|\, \mu_{\tilde{Y}_{rj}}\left(y_{rj}\right) \geq \alpha\right\},\ \underset{y_{rj}}{\text{Max}}\left\{y_{rj} \in Y_{rj} \,\middle|\, \mu_{\tilde{Y}_{rj}}\left(y_{rj}\right) \geq \alpha\right\}\right] \tag{3.5}$$

In fuzzy DEA models, all observations are assumed to be fuzzy numbers, and crisp values can be represented by single membership functions which have only one value. $\tilde{X}_{ij}$ and $\tilde{Y}_{rj}$ sets' α-cut intervals show how to change input and output values at any α level (Kao and Liu, 222: 898).

The fuzzy DEA model transformation is shown in (3.6) (Saati and Memariani, 2005: 615):

$$\tilde{E}_k = \sum_{r=1}^{s} u_r\left(Y_{rk}{}^{L}, Y_{rk}{}^{M}, Y_{rk}{}^{U}\right) \rightarrow \text{maximum}$$

$$\sum_{i=1}^{m} v_i\left(X_{ik}{}^{L}, X_{ik}{}^{M}, X_{ik}{}^{U}\right) = 1$$

$$\sum_{r=1}^{s} u_r\left(Y_{rj}{}^{L}, Y_{rj}{}^{M}, Y_{rj}{}^{U}\right) - \sum_{i=1}^{m} v_i\left(X_{ij}{}^{L}, X_{ij}{}^{M}, X_{ij}{}^{U}\right) \leq 0$$

$$u_r, v_i \geq \varepsilon \tag{3.6}$$

To find α-cuts, arithmetical operations on triangular fuzzy numbers are used. With this operations, an interval that shows lower and upper bounds in different α levels is found. Application of α-cut interval operations to fuzzy inputs and outputs are shown in (3.7), (3.8) and (3.9) (Saati et al, 2002: 259).

$$\mu_{\tilde{X}_{ij}} \geq \alpha \qquad \begin{array}{l} \dfrac{X_{ij} - X_{ij}{}^{L}}{X_{ij}{}^{M} - X_{ij}{}^{L}} \geq \alpha \\[2ex] \dfrac{X_{ij}{}^{U} - X_{ij}}{X_{ij}{}^{U} - X_{ij}{}^{M}} \geq \alpha \end{array} \tag{3.7}$$

$$\mu_{\tilde{Y}_{rj}} \geq \alpha \qquad \frac{Y_{rj} - Y_{rj}^{L}}{Y_{rj}^{M} - Y_{rj}^{L}} \geq \alpha \qquad \frac{Y_{rj}^{U} - Y_{rj}}{Y_{rj}^{U} - Y_{rj}^{M}} \geq \alpha \tag{3.8}$$

$$\tilde{X}_{ij} \in \left[\alpha X_{ij}^{M} + (1-\alpha) X_{ij}^{L} \ , \ \alpha X_{ij}^{M} + (1-\alpha) X_{ij}^{U}\right]$$
$$\tilde{Y}_{rj} \in \left[\alpha Y_{rj}^{M} + (1-\alpha) Y_{rj}^{L} \ , \ \alpha Y_{rj}^{M} + (1-\alpha) Y_{rj}^{U}\right] \tag{3.9}$$

By substituting the new varibles with α-cuts the model can be written as follows (Azadeh, 2008: 1354) (Saati et al., 2002: 260):

$$\tilde{E}_k = \sum_{r=1}^{s} u_r \left[\alpha Y_{rk}^{M} + (1-\alpha) Y_{rk}^{L} \ , \ \alpha Y_{rk}^{M} + (1-\alpha) Y_{rk}^{U}\right] \rightarrow \max imum$$

$$\sum_{i=1}^{m} v_i \left[\alpha X_{ik}^{M} + (1-\alpha) X_{ik}^{L} \ , \ \alpha X_{ik}^{M} + (1-\alpha) X_{ik}^{U}\right] = 1$$

$$\sum_{r=1}^{s} u_r \left[\alpha Y_{rj}^{M} + (1-\alpha) Y_{rj}^{L} \ , \ \alpha Y_{rj}^{M} + (1-\alpha) Y_{rj}^{U}\right]$$

$$- \sum_{i=1}^{m} v_i \left[\alpha X_{ij}^{M} + (1-\alpha) X_{ij}^{L} \ , \ \alpha X_{ij}^{M} + (1-\alpha) X_{ij}^{U}\right] \leq 0$$

$$u_r \ , v_i \ \geq \varepsilon \tag{3.10}$$

$$(E_k)_\alpha = \sum_{r=1}^{s} u_r \tilde{Y}_{rk} \rightarrow \max imum$$

$$\sum_{i=1}^{m} v_i \tilde{X}_{ik} = 1$$

$$\sum_{r=1}^{s} u_r \tilde{Y}_{rj} - \sum_{i=1}^{m} v_i \tilde{X}_{ij} \leq 0$$

$$\alpha X_{ij}{}^{M} + (1-\alpha) X_{ij}{}^{L} \leq \tilde{X}_{ij} \leq \alpha X_{ij}{}^{M} + (1-\alpha) X_{ij}{}^{U}$$

$$\alpha Y_{rj}{}^{M} + (1-\alpha) Y_{rj}{}^{L} \leq \tilde{Y}_{rj} \leq \alpha Y_{rj}{}^{M} + (1-\alpha) Y_{rj}{}^{U}$$

$$u_r, v_i \geq \varepsilon \tag{3.11}$$

Model (3.11) is a nonlinear programming problem. In order to linearize this model some variable substitutions are performed. $\overline{Y}_{rj} = u_r \tilde{Y}_{rj}$, $\overline{X}_{ij} = v_i \tilde{X}_{ij}$ By these substitutions, the nonlinear programming model will become a linear programming problem as follows (Saati et al., 2002: 260):

$$(E_k)_\alpha = \sum_{r=1}^{s} \overline{Y}_{rk} \rightarrow \max imum$$

$$\sum_{i=1}^{m} \overline{X}_{ik} = 1$$

$$\sum_{r=1}^{s} \overline{Y}_{rj} - \sum_{i=1}^{m} \overline{X}_{ij} \leq 0$$

$$v_i \left[\alpha X_{ij}{}^{M} + (1-\alpha) X_{ij}{}^{L}\right] \leq \overline{X}_{ij} \leq v_i \left[\alpha X_{ij}{}^{M} + (1-\alpha) X_{ij}{}^{U}\right]$$

$$u_r \left[\alpha Y_{rj}{}^{M} + (1-\alpha) Y_{rj}{}^{L}\right] \leq \overline{Y}_{rj} \leq u_r \left[\alpha Y_{rj}{}^{M} + (1-\alpha) Y_{rj}{}^{U}\right]$$

$$u_r, v_i \geq \varepsilon \tag{3.12}$$

4. Financial Efficiency Measurement Via Fuzzy DEA

Cement sector, becomes important owing to rising of building and substructure activities due to urbanization and population. Turkish cement firms catch international standarts by means of regeneration and modernization at works that are done with the aim of high customer satisfaction. Turkish cement sector has a strong capability of competition in the international cement market.

The aim of this study is to use minimum, average and maximum values of financial ratios for measuring relative efficiency of 15 cement firms via Fuzzy DEA.

In this study, 15 cement firms', listed in ISE, efficiency measurement processes are examined. The DMUs used in analysis and their products are defined on Table 1

Table 1: Cements Firms And Their Products

CEMENT FIRMS	PRODUCTS
ADANA	Cement, Clinker, Ready mixed concrete,
AFYON	Cement, Clinker
AKCANSA	Cement, Clinker, Ready mixed concrete,
L.ASLAN	Cement, Clinker
BATI	Cement, Clinker, Ready mixed concrete, Fine gravel
BATISOKE	Cement, Clinker
BOLU	Cement, Clinker, Ready mixed concrete, Fine gravel
BURSA	Cement, Clinker, Ready mixed concrete
CIMENTAS	Cement, Ready mixed concrete
CIMSA	Cement, Ready mixed concrete
GOLTAS	Cement, Ready mixed concrete
KONYA	Cement, Clinker
MARDIN	Cement, Clinker, Ready mixed concrete
NUH	Cement, Clinker, Ready mixed concrete
UNYE	Cement, Clinker

The data is obtained from the cement firms' balance sheets and income statements between 2006-2010. The most important stage in DEA is to define DMUs' inputs and outputs. Different input and output values cause different efficiency scores, and hence, their values should represent the sector's condition best. Also, the number of DMUs should be at least $m + s + 1$.

Inputs and outputs that are determined in analysis consist of financial ratios used for financial analysis. Current ratio, liquid ratio, cash ratio and financial leverage ratio are used as inputs, and assets profit margin, equity profit margin, net profit margin and gross margin are used as outputs. Inputs' and outputs' formulas are given in Table 2 and Table 3.

Table 2: Inputs

INPUTS	FORMULAS
Current Ratio (X_1)	Current Assets/Short Term Debts
Liquid or Asid-Test Ratio (X_2)	Current Assets - Stocks /Short Term Debts
Cash Ratio (X_3)	Liquid Assets/Short Term Debts
Financial Leverage Ratio (X_4)	Total Debts/Total Assets

Table 3: Outputs

OUTPUTS	FORMULAS
Assets Profit Margin (Y_1)	Net Profit/Total Assets
Equity Profit Margin (Y_2)	Net Profit/Equity
Net Profit Margin (Y_3)	Net Profit/Net Sales
Gross Margin (Y_4)	Net Profit/Gross Profit

To set fuzzy DEA models we have obtained triangular fuzzy numbers using inputs' and outputs' minimum, average and maximum values. These input values with triangular fuzzy numbers are given in Table 4, and output values with triangular fuzzy numbers are given in Table 5

Table 4: Input Values

DMU	INPUTS											
	X_1			X_2			X_3			X_4		
ADANA	1,76	7,27	12,27	1,08	6,11	11,29	0,30	4,36	9,43	0,06	0,08	0,14
AFYON	3,85	4,65	5,53	3,22	3,66	4,65	2,03	2,54	3,16	0,13	0,16	0,17
AKCANSA	1,33	1,88	3,38	0,86	1,44	2,86	0,15	0,48	1,64	0,14	0,27	0,33
L.ASLAN	0,78	1,48	2,06	0,64	1,21	1,56	0,04	0,23	0,54	0,26	0,38	0,51
BATI	3,22	3,63	4,61	2,30	2,75	3,43	0,91	1,40	1,89	0,18	0,19	0,21
BATISOKE	4,30	6,13	8,03	2,83	4,18	4,90	1,50	2,74	3,57	0,08	0,10	0,13
BOLU	4,40	8,00	10,68	3,35	6,39	9,15	1,13	3,36	6,14	0,06	0,08	0,11
BURSA	2,94	4,50	5,18	1,98	3,11	3,58	0,22	0,90	1,18	0,18	0,21	0,26
CIMENTAS	0,77	1,22	2,17	0,45	0,86	1,67	0,07	0,36	0,96	0,24	0,37	0,50
CIMSA	1,04	1,38	1,81	0,66	0,94	1,21	0,03	0,22	0,39	0,18	0,24	0,30
GOLTAS	2,55	2,90	3,37	1,99	2,27	2,62	1,03	1,32	1,59	0,15	0,20	0,33
KONYA	4,54	6,92	9,09	3,19	5,34	7,36	0,73	3,24	5,77	0,10	0,12	0,15
MARDIN	3,12	4,90	5,88	2,31	4,04	5,13	0,88	2,61	3,92	0,10	0,11	0,14
NUH	2,00	2,46	2,95	1,63	1,98	2,40	0,20	0,49	0,93	0,21	0,24	0,28
UNYE	4,37	5,09	5,57	3,61	4,40	4,81	2,21	3,15	3,82	0,15	0,18	0,23

Table 5: Output Values

DMU	OUTPUTS											
	Y_1			Y_2			Y_3			Y_4		
ADANA	0,12	0,19	0,27	0,13	0,21	0,29	0,27	0,42	0,58	0,78	0,99	1,16
AFYON	0,00	0,10	0,24	0,00	0,12	0,28	0,00	0,13	0,30	0,00	0,51	1,09
AKCANSA	0,05	0,10	0,16	0,07	0,14	0,22	0,07	0,17	0,27	0,51	0,62	0,83
L.ASLAN	0,00	0,06	0,16	0,00	0,10	0,23	0,00	0,07	0,17	0,00	0,22	0,51
BATI	0,02	0,07	0,17	0,03	0,10	0,24	0,03	0,12	0,27	0,24	0,44	0,72
BATISOKE	0,00	0,06	0,15	0,00	0,06	0,18	0,01	0,13	0,36	0,04	0,42	0,81
BOLU	0,06	0,17	0,30	0,07	0,18	0,33	0,10	0,25	0,45	0,54	0,69	0,96
BURSA	0,02	0,11	0,19	0,02	0,17	0,31	0,02	0,10	0,16	0,11	0,36	0,52
CIMENTAS	0,00	0,04	0,09	0,00	0,06	0,14	0,00	0,10	0,23	0,00	0,37	0,64
CIMSA	0,07	0,13	0,26	0,10	0,17	0,31	0,12	0,24	0,50	0,48	0,72	1,38
GOLTAS	0,00	0,04	0,12	0,00	0,05	0,16	0,00	0,08	0,26	0,00	0,25	0,70
KONYA	0,06	0,11	0,20	0,07	0,13	0,23	0,13	0,21	0,31	0,55	0,62	0,69
MARDIN	0,27	0,32	0,37	0,31	0,36	0,41	0,33	0,44	0,62	0,70	0,82	1,03
NUH	0,05	0,14	0,22	0,07	0,18	0,27	0,07	0,19	0,32	0,46	0,56	0,72
UNYE	0,16	0,21	0,27	0,18	0,26	0,33	0,24	0,35	0,46	0,68	0,73	0,76

By using input values in Table 4 and output values in Table 5 we set 15 different fuzzy DEA models. We have used 0.50 as an α level. In α = 0.50, by solving these Fuzzy DEA models the relative efficiency scores in Table 6 are found.

Table 6: Efficieny Scores For Each DMU

DMU	Efficiency Score
ADANA	1
AFYON	0.847
AKCANSA	1
L.ASLAN	0.75
BATI	0.709
BATISOKE	0.64
BOLU	0.944
BURSA	0.715
CIMENTAS	0.84
CIMSA	1
GOLTAS	0.618
KONYA	0.689
MARDIN	1
NUH	1
UNYE	1

5. Conclusion

One of the best way of increasing competition advantage for businesses is to use resources effeciently. To define whether or not a business uses its resourses efficiently is possible with the help of efficiency measurement. Efficiency measurement between businesses has a very important place in performance measurement. Relative efficiency measurement determines the performance of businesses in their own sectors. Interfirm comparisons provide benchmarking, and performance measurement expertise in helping bussinesses improve their performance.

In this study, Financial Ratio Analysis is utilized for examining the financial performance of the 15 cement firms listed on ISE. Four inputs (current ratio, liquid ratio, cash ratio and financial leverage ratio) and four outputs (assets profit margin, equity profit margin, net profit margin and gross magrin) are used to set the fuzzy DEA models. Triangular fuzzy numbers for inputs and outputs are determined. Triangular fuzzy numbers have lower, average and upper bounds for each input and output. In 15 fuzzy DEA models, 128 variables and there were 256 constraints are used for each model. The efficiency scores for each DMU are calculated while solving fuzzy DEA models. The conclusions are shown in Table 4.6.

In conclusion, six efficient DMUs called ADANA, AKCANSA, CIMSA, MARDIN, NUH and UNYE Cement firms are found. The DMUs called BOLU, AFYON and CIMENTAS are almost efficient. On the other hand all of the other firms are inefficient.

It may be suggested that inefficient firms should increase their net sales and review their price and discount policies. By reducing input costs and increasing sales, inefficient firms may increase their profits. Inefficient fims should save on some resources to increase their net profits. In a consequence of improved profitability ratios, the market value of inefficient firms would rise. Rising market value provides positive results for the firm in its sector.

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