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DETERMINING THE EFFICIENCY OF CONCRETE COMPANIES RANKED IN TOP 1000 MANUFACTURING FIRMS TRADING IN ISE: A MULTI-CRITERIA DATA ENVELOPMENT ANALYSIS MODEL

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ABSTRACT

The purpose of this study is to measure and evaluate the efficiency of 11 concrete companies ranked in top 1000 manufacturing firms in 2002 in Turkey, using a multi-criteria Data Envelopment Analysis (DEA) methodology. Current ratio, leverage, inventory turnover ratio, machinery and equipment, size of the company in terms of shareholders equity, and cash flow were used as inputs of the model. The outputs used in this analysis incorporated profitability, productivity, and stock performance of the company. Efficiencies of the companies were measured using the data provided by Istanbul Stock Exchange (ISE) and Istanbul Chamber of Industry (ICI). Results provide management with information regarding the relatively best companies in the observation sets and locate the relatively inefficient companies by comparison with the best practice ones. At last some suggestions are made for the inefficient companies.

Keywords: *Data Envelopment Analysis, Performance Measurement, Profitability*

ÖZET

Çalışmanın amacı 2002 yılında imalat sanayi firmaları içinde ilk 1000'de yer alan 11 çimento firmasının etkinliklerini Veri Zarflama Analizi (VZA) ile hesaplamaktır. Cari oran, kaldıraç oranı, stok devir hızı, makine tesis cihazlar, özsermaye ve nakit akışlar firmaların girdileri olarak kullanılmıştır. Çıktılar ise firmaların karlılık, verimlilik ve borsa getirisidir. Veriler İstanbul

Menkul Kıymetler Borsası (İMKB) ve İstanbul Sanayi Odası (İSO) yayınlarından derlenmiştir. Analizler sonunda firmaların görece etkinlikleri bulunmakta, etkin olmayan firmaların neden etkin olmadıkları, hangi girdilerin ne oranda fazla veya hangi çıktıların ne oranda eksik olduğu belirlenmektedir.

Anahtar Kelimeler: *Veri Zarflama Analizi, Analitik Hiyerarşi Proses, Veri Zarflama Analitik Hiyerarşi Prosesi (VZAHP), Karar Verme.*

INTRODUCTION

Comparative performance evaluation is very important for the optimum management of an organization [Gülen 1994]. The performance of an organization is usually evaluated by comparison with other organizations in the same industry.

The efficiency of companies traditionally has been measured by ratio analysis and econometric methods on the basis of which a production function or a cost function is estimated.

Ratio analysis is limited to only two factors, one input and one output. When multiple outputs are produced using multiple inputs ratio analysis is not an appropriate method. Econometric methods are superior to ratio analysis mainly because the model takes into account the interaction between a number of inputs and outputs.

Data envelopment analysis (DEA) which is a performance measurement method was developed by Charnes, Cooper and Rhodes in 1978 [Charnes et. al., 1978]. DEA determines companies' relative efficiency on the basis of their outputs/inputs

The purpose of the study is to estimate the relative efficiency of cement production companies that are ranked in top 1000 of Turkey in 2002, using input and output factors provided in Istanbul Stock Exchange's (ISE) and Istanbul Chamber of Industry's (ICI) report. Outputs are multi-perspective measures of the performance of companies while inputs reflect the factors that are stated as the factors that affect the performance.

All facilities belong to private ownership. Privatization was completed by September 1998. Concrete production industry is one of the top industries in Turkey in terms of modern technology utilized in this industry. Machinery and all equipments are produced domestically. It has been the leading company of Europe in concrete production with 37.488.051 tons in 1998 and keeps the eighth place in the world. Table 1 shows the production and consumption values of countries. On the other hand, industry is facing with some problems as well. The high energy prices, lack of fully equipped ports are some of those problems.

Table 1. Concrete Producing Countries

	Production			Consumption		
	1997 (Mt)	**1998** (Mt)	**1999** (Mt)	**1997** (Mt)	**1998** (Mt)	**1999** (Mt)
China	490.0	500.0	510.0	493.0	495.0	485.0
Japan	95.8	86.9	86.9	78.6	76.0	76.0
USA	79.2	82.6	84.6	90.9	96.3	102.2
India	76.2	80.0	84.0	73.5	75.6	80.6
S. Korea	59.8	47.0	52.0	61.5	44.5	48.5
Brazil	38.0	39.2	38.3	38.1	39.1	38.51
Italy	34.4	35.0	35.9	33.7	34.3	35.0
Germany	31.7	31.5	31.6	34.3	32.8	33.0
Turkey	36.3	37.5	34.8	32.6	34.1	31.6
Spain	29.7	31.2	32.1	26.8	29.5	30.7
Mexico	27.8	28.0	28.7	24.3	25.7	25.8
Russia	26.7	26.2	26.0	25.9	25.2	25.2
Taiwan	21.6	21.0	20.0	21	21.5	22.0
Thailand	37.3	28.8	29.5	35.3	21.4	18.8
Iran	19.2	19.0	19.5	18.6	18.0	18.5

1. LITERATURE REVIEW

Neely, George and Platts [1995] describes performance measurement as a process of quantifying the efficiency and effectiveness of action that leads to performance. Performance measurement is important in order to guide top managers in decision making, in defining the activities of planning, organising, controlling, commanding and co-ordinating of an organization.

A company is an economic enterprise and its basic goal, with the exception of charitable corporations is to maximize its profit [Akal, 1994]. Profit maximization can not be the only goal of companies. This can be obtained by selling shares or by investing in bonds, but then earnings per share will decrease. If maximizing earning per share is assumed as the only goal of company, this would be insufficient, because earning per share does not consider the risk, period and timing of expected income. Maximization of market value of company for shareholders is a goal of firms [Brigham and Ehrhardt, 2002]. Productivity is also a goal because it is a crucial for optimizing performance. There are, however, some critiques against financial measures such as the thought that firms can not be totally evaluated by financial variables [Barker, 1995] and the present or future performance of firms can not be evaluated by using the past values of companies. Despite this, financial measures are frequently used to evaluate the performance of companies [Yurdakul, 2003], [Robertson, 1997]. Kaplan R. S. and Norton D. P. (1996) recognize that a single measure of performance can not provide a clear concentration on the critical mission of an organization. Consequently, a unique performance measure or a unique goal is insufficient for companies. Business performance should be measured with multidimensional perspectives. All the measures; profitability, productivity, and share value are the common goals of companies. In this study these measures are used as the outputs of the model.

Performance of companies can be affected from many factors such as, quality, innovation, debts, efficiency, effectiveness, some enviromental situations [Luo and Park, 2001]; dynamism, complexity, hostility and some other unobservable factors [Jacobson, 1990]; corporate culture, access to scarce resources, management skill and luck. In the study cash flow, current ratio, leverage, firm size, inventory turnover, machinery and equipment are used as inputs of the model.

Cash flow shows the ability of the company's cash reserves to cover company's debts. In long term, the ability of fulfillment the responsibilies by companies depends on profitabilities and debts. This ability serves to survive companies in unusual times. Cash reserves is also important to provide raw materials and equipments in convenient conditions, to utilize from cash discounts and suitable investment opportunities. Leverage ratio shows the extent to which debt is used in financing the company's total assets. An increase in this

ratio means the debt and the risk level of the company are increased. This causes a high interest rate in receiving credit. It is assumed that 50% of leverage rates are normal. A firm with high earnings rate would maintain a relatively lower debt ratio because of its ability to finance itself from internally generated funds [Toy, et al, 1974]. The value of current ratio shows the ability of the company's total current assets to cover its short term obligations. High value of current ratio is good for companies for paying short term debts but very high values display that company has idle funds which are not used in productive ways for more profits. As a general evaluation, the value of a current ratio of 2 is assumed enough [Helfert, 1977]. In developing countries, because banks prefer to give short term debts, current ratio of 1.5 is said to be enough [Bolak, 1998].

In competitive areas large firms have more advantages than small firms. Because they have large market shares, they earn more. Large firms can work without high competition in the areas that high equity is necessary; this provides more profitability to them. Large firms are more innovative; spend more on technical innovation [Co, Chew, 1997] and more proffessional. Technology investments reduce costs, hence rise profitability. Besides, growth in sales decrease unit costs therefore it increases profitability. Consequently, performance is affected by firm size and machinery and equipment.

There are contradictory publications in literature about profitability and firm size. While Hall M., Weiss L. [1967], Schmalensee R. [1989], Lirely R. L. [2000], Fink, Koller [2002] mention the positive relation between firm size and profitability, Osborn [1970], Elliot [1972], Toy [1974], Dhawan [2001], claim a negative relation between profitability and firm size. In F. R. Kaen and H. Baumann's [2004] study, nearly half of their manufacturing industries firm profitability increases at a decreasing rate and eventually declines as firms become larger. For most of the remaning manufacturing industries, no relation exists between size and profitability. They also find that profitability is negatively correlated with the number of employees for firms of a given size measured in terms of total assets and sales.

Technology investments provides more products with less manpower. Large firms spend more on mac&eqp. Since large firms are found to be less risky, they can get credits with less interest rates, and because small firms can get credits with high interest rates, their production costs become high and

therefore their productivity decrease. Existing literature on positive relationship between productivity and leverage considers the situation that increased debt can lead to an increased managerial effort in operating the firm by additional investment in tangible assets, thus increasing their productivity [Anderson, Prezas, 1999] or firms that experience disciplinary effects of debt will manage their tangible assets more efficiently and will have more productive workers [Winn, 1997]. Other factors thus have effects on productivity are; education, skill and capacity of workers, and to be open to new investments of firms [Haris, 1999]. Fortine, Helpman [Kald, Nilsson, 2000], Brynjolfsson, Hitt [2000] determine direct impact of technology investmenst on productivity and Bernstein [1998] determines the impact of quality of workers, R&D and firm size on productivity.

In companies money flows from cash to inventory and long term assets, and returns to cash from amortisation of long term assets and sales of inventories. Inventory turnover ratio analyzes how many times the company's inventories have been sold in a year. A high value of this ratio reveals the profitability of the company. Inventories are low liquidity entries in assets, therefore high inventory turnover ratio is positive. Low inventory turnover ratio cause to cash flows slow down and this causes to rise the need of net working capital. Because an increase in inventory turnover ratio decreases inventory costs, it increases cash flows, profitabilities and productivities. Larin et al., [Hitt, et. al., 2002] determine positive effects of technology investments on inventory turnover.

Market Value/Book Value is the proportion of the price of a share to the shareholders equity per share. It is possible to see high MV/BV depending on feeling of confidence for company but, a ratio over the average shows price of share is expensive and under the average shows share is cheap. The most important factors that effect the value of shares are profitability and components of profitability. Sector [Ray, Tsay, 2000], interest rates and expectations are effective factors in determining market value of company [Stock, 1981]. Chan, Hamao and Lakanishok [1992], Fama and French[1992] state that MV/BV is effective to express expected income. The ratio is a good explanatory variable to measure share performance [Gagne, Reddy, 1999]. The firms owning high value of MV/BV, have high expected incomes of shares. Fama, French [1992]

Morck, Shleifer, Vishny [1998] and McConnell, H. Servaes [1990] determine that this ratio is effected from income.

2. THE MODEL

Data envelopment analysis is used to determine whether a company is less productive or inefficient, compared to other companies in the model.

2.1. Methodology

For the empirical research, we selected 11 companies in Turkey as our peer group. Data for this study was collected from ISE and ICI report.

In the study total six inputs and three outputs were identified. Data set is given in Table 2.

2.2. Data Envelopment Analysis

Data envelopment analysis (DEA) is a linear programming application that compares a number of service units of the same type based on their inputs and outputs. The model solution result indicates if a particular unit is less productive, or inefficient, compared to other units. The value of outputs is forced to be 1 or less by the next set of constraints. In general terms, the efficiency of a particular unit can be defined as

$$efficiency = \frac{value\ of\ outputs}{value\ of\ inputs}$$

It is not possible for any service unit to be more than 100% efficient; thus, the efficiency of a unit must be less than or equal to 1.

$\frac{value of\ outputs}{value of\ inputs} \leq 1$ Converting this to standard linear form, *value of outputs* $\leq$ *value of inputs*

A standard model can be expressed as [Talluri, 2000]

$$Max\, Z^{o} = \frac{\sum_{l=1}^{L} v_l^o y_l^o}{\sum_{k=1}^{K} u_k^o x_k^o}$$

s.t

$$\sum_{l=1}^{L} v_l^o y_l^n \,/\, \sum_{k=1}^{K} u_k^o x_k^n \le 1; \qquad n = 1,2....,N$$

$$v_l^o, u_k^o \ge 0; \quad k = 1,2,...,K; \;\; l = 1,2,...,L$$

Where

Z : efficiency score

x_k^n : k-th input value of n-th DMU

y_l^n : l-th output value of n-th DMU

v_l^n, u_k^n weights attached to outputs and inputs of DMU n

Converting this to standard linear form, value of outputs $\le$ value of inputs implies

value of outputs -value of inputs ≤ 0

$$Max W^{0} = \sum_{l=1}^{L} v_l^o y_l^o$$

s.t

$$\sum_{k=1}^{K} u_k^o x_k^1 = 1$$

$$\sum_{l=1}^{L} v_l^o y_l^n - \sum_{k=1}^{K} u_k^o x_k^n \le 0;\ \ n = 1,2,...,N;\ k = 1,2,...,K;\ \ l = 1,2,...,L$$

According the DEA calculation rules, both input and output factors can not have negative values [Halme et al. 2002]. If negative value occurred in any factor, a positive value should be added to all DMU for adjusting to be positive.

2.3. Study Variables

Business performance named as outputs of cement production companies is measured by profitability, productivity, stock performance of the companies. Net profit margin is used for profitability, gross value added / number of employees is used to measure the productivity of firms, stock performance of companies are measured by market value / book value (MV/BV). Independent variables (inputs) that can affect business performance used in this research are, current ratio (total current assets / total current liabilities), leverage (total liabilities / total assets), machinery plant & equipment / employees (mac & eqp), firm size (shareholders equity), inventory turnover, and cash flow ratio (profit before tax + depreciation +expenses not requiring cash outflow / short term debt + long term debt).

Independent variables in this study affect the performance (dependent) variables positively except leverage (Bayyurt, 2004). Thus, the leverage values of each firm in table 2 have been inverted to show the negative relationship.

The objective of the model is to determine whether a company is inefficient, if the value of the objective function equals 1 the company is efficient; if it is less than 1, it is inefficient.

Table 2: Input/output data for Companies

	Inputs							Outputs		
Company	Current Ratio	Leverage & (1/Leverage)		Inv. Turn.	Mac & eqp	Size	Cash Flow	Profit.	Prod.	Stock Exch.
Afyon	2,6707	53,03	0,0189	7,016	5320,946	4939506	0,699	11,404	69591,769	9,51
Akcansa	2,6644	20,11	0,0497	7	181991,744	19453822	0,485	7,5	69835,284	2,68
Bolu	2,31	28,5	0,0351	4,5	72713,562	94867853	0,847	22,51	111341,25	1,38
Bati	2,97	26,2	0,0382	14,55	13201,459	84149084	0,778	10,18	68318,469	0,65
Bursa	2	28,9	0,0346	5,32	37856,847	47548076	0,7394	12,1	75201,189	2,83
Cimsa	2,76	20,1	0,0498	5,82	133294,532	184580340	1,156	19,13	209309,46	1,7
Cment	2,3	22,9	0,0437	4,7	28432,548	65236473	0,5294	8,06	53315,919	4,7
Ecyap	2,28	49,1	0,0204	4,48	122888,098	87952436	0,3188	7,9	57882,623	1,66
Goltas	1,31	30,4	0,0329	8,33	34819,493	50693331	0,9428	19,95	75104,365	1,2
Haznedar	2	57,9	0,0173	3,73	6596,433	5414557	0,0903	2,52	58047	1,7
Nigde	3,09	36,79	0,0272	3,51	13145,337	16177173	1,3199	26,29	126659,63	4,2

2.4. Model Solution and Results

The solution to the DEA models was carried out using the optimization modeling system for linear programming called Microsoft Excel Solver. Output-oriented with constant return to scale model has been applied. In an output-oriented model, the calculations aim at improving the performance of a concrete company by maximizing its outputs while consuming at most the observed input levels. The emphasis here is more on the output side, as in the case of maximizing profitability, productivity and share performance. Returns to scale refers to a technical property of production that examines changes in output subsequent to a proportional change in all inputs where all inputs increase by a constant. If output increases by that same proportional change then there are constant returns to scale, if output increases by less than that proportional change, there are decreasing returns to scale and if output increases by more than that proportion, there are increasing returns to scale.

The efficiency score of a certain company is given by the objective function value of its DEA model. The DEA results for the 11 companies that are

given in Table3 identified the comparatively efficient best companies (score = 1) and relatively inefficient companies (score < 1) and efficiency reference set.

According to the analysis, 5 out of 11 companies were found inefficient. These are Akcansa, Bati, Bursa, Cment, and Ecyap companies. The distribution of inefficient companies over efficiency scores range from 0,6361 to 0,9581. The relatively most inefficient company is Bati.

In Table 4, efficiency reference set of each unit is given (i.e. 0,1348 for Afyon, 0,0165 for Bolu, 0,0544 for Cimsa, 0,7722 for Haznedar and 0,1849 for Nigde) represents the relative weight assigned to that efficient unit in calculated the efficiency rating for Akcansa. These relative weights are the shadow prices that are associated with the respective efficient unit constraints in the linear programming solution.

In addition to the identification of inefficient companies and their efficiency reference set, DEA provides additional insights about the level of inefficiency for the inefficient companies. The level of inefficiency is given by the excess resources (inputs) and/or deficient outputs produced by the inefficient companies. Excess inputs or deficient outputs are calculated by subtracting the actual input/output values of a given company from the ideal values of the composite (best practice) company.

Table 3: Efficiency scores

Afyon	Akcnsa	Bolu	Bati	Bursa	Cimsa	Cment	Ecyap	Goltas	Hazndr	Nigde
1	0,7685	1	0,6361	0,8317	1	0,8477	0,9581	1	1	1

Table 5 shows the results of the input/output vector for the composite company and the level of inefficiency for the inefficient companies. The composite company's value is formed by using the weighted average inputs of the corresponding companies in the efficiency reference set. The table shows the values as percentage of excess inputs and deficient outputs that existed in inefficient companies.

Table 4: Efficient peers and weights

	Afyon	**Bolu**	**Cimsa**	**Goltas**	**Haznedar**	**Nigde**
Akcansa	0,1348	0,0165	0,0544		0,7722	0,1849
Bati		0,0135	0,0077		0,6395	0,5302
Bursa	0,2176	0,1622	0,1457	0,0189		0,1997
Cment	0,4893	0,0072			0,2156	0,1226
Ecyap	0,0411	0,2828			0,5598	

The results that pertain to either the potential reduction in the usage of inputs or the potential increase in the production of outputs for the least efficient company Bati can be summarized as follows:

- A potential increase of 57,21 % in profitability.

- A potential increase of 57,21 % in productivity.
- A potential decrease of 414,76 % in stock exchange.
- A potential decrease of 15,96 % in 1/leverage (1/leverage =total assets/total liabilities)
- A potential decrease of 70,09 % in inventory turnover.
- A potential decrease of 82,47 % in size.

Table 5: Virtual inputs /outputs

	Current Rati		**Leverage**		**Inv. Turn.**	
Afyon	2,67	*0,00%*	0,0189	*0,00%*	7,02	*0,00%*
Akcansa	2,66	*0,00%*	0,0497	*51,35%*	4,87	*30,48%*
Bolu	2,31	*0,00%*	0,0351	*0,00%*	4,5	*0,00%*
Bati	2,97	*0,00%*	0,0382	*31,05%*	4,35	*70,09%*
Bursa	2	*0,00%*	0,0346	*33,25%*	3,96	*25,50%*
Cimsa	2,76	*0,00%*	0,0498	*0,00%*	5,82	*0,00%*
Cment	2,13	*7,24%*	0,0437	*62,13%*	4,7	*0,00%*
Ecyap	2,12	*17,43%*	0,0204	*0,00%*	3,65	*18,55%*
Goltas	1,31	*0,00%*	0,0329	*0,00%*	8,33	*0,00%*
Haznedar	2	*0,00%*	0,0173	*0,00%*	3,73	*0,00%*
Nigde	3,09	*0,00%*	0,0272	*0,00%*	3,51	*0,00%*

	Mac & eqp		**Size**		**Cash Flow**	
Afyon	5.320,95	*0,00%*	4.939.506,00	*0,00%*	0,7	*0,00%*
Akcansa	16.699,39	*90,82%*	19.453.822,14	*0,00%*	0,49	*0,00%*
Bolu	72.713,56	*0,00%*	94.867.856,00	*0,00%*	0,85	*0,00%*
Bati	13.201,46	*0,00%*	14.748.913,48	*82,47%*	0,78	*0,00%*
Bursa	35.658,97	*5,81%*	47.548.075,57	*0,00%*	0,74	*0,00%*
Cimsa	133.294,53	*0,00%*	184.580.336,00	*0,00%*	1,16	*0,00%*
Cment	6.162,41	*78,33%*	6.252.568,13	*90,42%*	0,53	*0,00%*
Ecyap	24.475,70	*80,08%*	30.063.884,28	*65,82%*	0,32	*0,00%*
Goltas	34.819,49	*0,00%*	50.693.332,00	*0,00%*	0,94	*0,00%*
Haznedar	6.596,43	*0,00%*	5.414.557,00	*0,00%*	0,09	*0,00%*
Nigde	13.145,34	*0,00%*	16.177.173,00	*0,00%*	1,32	*0,00%*

	Profit.		Prod.		Stock Exch.	
Afyon	11,4	*0,00%*	69.591,77	*0,00%*	9,51	*0,00%*
Akcansa	9,76	*30,12%*	90.866,61	*30,12%*	3,49	*30,12%*
Bolu	22,51	*0,00%*	111.341,25	*0,00%*	1,38	*0,00%*
Bati	16	*57,21%*	107.403,24	*57,21%*	3,35	*414,76%*
Bursa	14,55	*20,24%*	90.420,47	*20,24%*	3,4	*20,24%*
Cimsa	19,13	*0,00%*	209.309,45	*0,00%*	1,7	*0,00%*
Cment	9,51	*17,97%*	62.897,53	*17,97%*	5,54	*17,97%*
Ecyap	8,25	*4,37%*	66.843,21	*15,48%*	1,73	*4,37%*
Goltas	19,95	*0,00%*	75.104,37	*0,00%*	1,2	*0,00%*
Haznedar	2,52	*0,00%*	58.047,00	*0,00%*	1,7	*0,00%*
Nigde	26,29	*0,00%*	126.659,63	*0,00%*	4,2	*0,00%*

3. CONCLUSIONS and FUTURE WORK

Performance measurement is essential for every company that exists in the market. Companies must measure their performance in a multidimentional scale. Profitability, productivity, and stock performance are three of most vital common goals for the companies. There are many factors that can affect the performance of organizations such as financial structures, quality, innovation, R&D, corporate culture, etc. Cash flow, leverage, current ratio, firm size, machinery / equipment, and inventory turnover are the most effective factors on business performance. Independent variables affect the dependent variables positively except leverage. Thus, the leverage values of each firm have been inverted to show the negative relationship.

DEA is a powerful and efficient mechanism to evaluate efficiency of companies in Turkey. DEA efficiency analysis can be useful in strategic planning. In this study, six factors that has affect on business performance were used as inputs and three factors that reflect the performance were used as outputs to evaluate the relative efficiency of 11 concrete companies ranked in top 1000 ISE of Turkey. The least efficient company was identified and compared with the composite company using output maximization model. The output

maximization model provides information on how much the performance of a company can be improved using the same resources. Although DEA results tell nothing about the resource needs of companies, they say more about resource utilization. DEA offers many opportunities for an inefficient company to become efficient regarding its reference set of efficient units. The motivation for change is clear; other companies are able to achieve similar outputs with fewer resources.

Non financial variables that also affect the business performance should be included in later studies. For instance, sales returns or average defective ratio to measure production quality, absenteeisim, number of employee-employer disagreements or number of accidents for quality of work life, experience of top mangers, maturity, qualified workers for growth, salaries of employees, contribution to social associations to represent social aims of firms.

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