

Investigation of the Efficiency of Manufacturing Companies in Machinery and Equipment Industry Applying DEA Method

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Abstract

The lack of a suitable performance evaluation instrument is among the causes of unsuccessful promotion of organizational productivity by managers. In order to evaluate efficiency, Data Envelopment Analysis (DEA) was applied in the present research as a supplementary method for the traditional method of analyzing performance and financial statements. The sample includes all active companies in machinery and equipment industry listed in Tehran Stock Exchange between 2010 and 2014. Results indicated that the efficiency of these companies has followed a descending trend from 2010 to 2014. The average efficiency in this industry has increased in 2014. Nevertheless, machinery and equipment industry has been inefficient during these five years.

Key words: performance, efficient, inefficient, Data Envelopment Analysis

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Introduction

Today, considering the development and increasing significance of organizations in societies and their presence in a competitive world, it is very important to evaluate the performance of organizations and managers. Diversity indices has been issued as scales for evaluation of the performance of organizations and their managers. Performance evaluation aims to modify and promote organizational performance applying different management techniques. Since financial data are objective and reliable, they might be more suitable to evaluate the performance of manufacturing companies compared to other quantitative and qualitative indices [9]. Therefore, this research aims to measure the efficiency of machinery and equipment manufacturing companies applying financial information and using Data Envelopment Method as a rather conclusive, efficient and effective method that can indicate if the companies are successfully or unsuccessfully directed toward efficient allocation of resources. When it comes to evaluation of efficiency and performance, companies are investigated and their weak points and strong points are identified. The question is, how efficient and successful have the machinery and equipment manufacturing companies listed in Tehran Stock Exchange been in line with the specified objectives in their financial reporting information considering the efficiency indices. Since the experts and specialist have not reached an agreement about the weight of parameters and their determined values, evaluation of each company is an inaccurate and time-consuming process that can lead to incorrect results [8]. Therefore, in this study, qualitative methods are applied instead of quantitative methods.

Research History

The attempts taken to functionalize the relationship between the inputs and outputs and determine the maximum output that can be taken from the input, developed functions such as Cobb-Douglas, Leontief, Cauchy, constant, etc. in economic theories. For the first time, Pharell (1957) presented a boundary element method named Ferrell Efficiency Measure through which he defined the nonparametric measure of efficiency. Applying mathematical relations, the solitariness of the decision making unit from the mentioned measure was calculated as the scale of efficiency for that unit. In fact, presenting the structural description of models and utility measuring methods through increasing the outputs, and as a result, promotion of efficiency without increasing the inputs, Farrel founded the utility evaluation in mathematics [3]. Innovation of Data Envelopment Analysis goes back to the PHD thesis by Rhodes and Cooper (1978), who evaluated the performance of state schools in USA. Data Envelopment Analysis was added to the economic literature through the method innovated by Charnes, Cooper and Rhodes (CCR) [17]. Data Envelopment Analysis is a mathematical programming method to evaluate the efficiency of decision making units [9]. Efficiency is a managerial concept with a long history in the knowledge of management [10]. Efficiency determines if an organization has successfully applied its resources in line with production compared to the best performance in each period of time. Whenever the decision making unit has an input and an output, efficiency is defined as its output-input proportion. Of course, the input and output must be of similar type, for instance money, so that the output can be divided by the input [9]. A multiple set of input and output variables is applied in this method in order to determine the efficiency of a group of units under investigation. For each specifies set of input and output variables, a specific point is allocated to each of the units under investigation in Data Envelopment Analysis. The efficient measure is determined experimentally. Then, the units located on the efficient measure would be considered as efficient units, and those that are not, would be considered as being inefficient. DEA method determines the relative efficiency of the units through comparing companies that have or have not the standards of efficient companies. That's how DEA compares the considered company with a group of efficient companies categorized as top companies. If the characteristics of the studied company is in accordance with a group of top companies, it is considered to be efficient, otherwise, it will be categorized as an inefficient company. For instance, a company with higher current ratio, quick ratio, inventory turnover, and asset turnover have more chance to be categorized as an efficient company, while the higher leverage and debt-to-capital ratio, the more probability to be place within the group of inefficient companies [11]. In most cases, decision making units

apply several inputs in order to product several outputs. This causes some difficulties in calculation of efficiency. In such condition, efficiency is defined as:

Efficiency= (weighted output)/ (weighted input)

Feroz et al. (2003) showed that DEA technique can be a suitable supplementary method for relative analysis of financial ratios of firms. In a research named "Prediction of Bankruptcy through Data Envelopment Analysis", Kline et al. compared the performance of ranking model, linear programming, Data Envelopment Analysis, and decision tree analysis methods. Results showed that compared to other methods, Data Envelopment Analysis has better accuracy and application [7]. Malhotra et al. (2007) applied Data Envelopment Analysis to evaluate bonds. Proportions of long-term liabilities to total capital and total liability to total capital were considered as the model input and six financial ratios including interest coverage of earnings before interest and tax, interest coverage of before interest, tax, and depreciation of tangible and intangible assets, net cash to total liabilities, free cash flows to total liabilities, return on capital, and earning to sale were applied as model output. Thirty-four units were investigated. According to the results 8 companies were more efficient in terms of their ability to pay the main debt and its interest [13]. Duzakin and Duzakin (2007) evaluated the performance of different industrial divisions in Turkey. Three elements including net assets, the number of employees and gross value added were considered as input. Earning before tax and export earning was the outputs of Data Envelopment Analysis evaluation norm for all existing companies in each industry. A total of 65 companies were evaluated to be efficient, and 278 others were evaluated as being average in a far lower level [5]. Supachet Cahnsarn (2008) investigated the efficiency of thirteen commercial Thai banks between 2003 and 2006 through Data Envelopment Analysis [21]. Pasiouras (2008) tried to explain the relationship between risk and efficiency in banking industry through the effect of credit risk, off-balance-sheet activities, and international activities considering the explanatory banking variables and indices such as defaulted loans ratio as the DEA inputs. He found that these two categories are significantly related [18]. Sueyoshi and Mika (2009) applied Data Envelopment Analysis-Discriminant Analysis in order to investigate the effect of R & D costs on the financial performance of companies in Japan. Results showed that the effect of R & D costs on financial performance depends on the type of industry [20]. Abbaszade et al. (2013) investigated the relationship between the capital structure and efficiency in 18 governmental and private banks through DEA method. The input variable included the number of employees, deposits, and fixed assets. The model output was the facilities in frame of commercial law. According to the results, there is a significant relationship between capital structure and profitability of banks [1]. Mansuri, Ebrahimi and Ramezani (2014), applied a combination of DEA and TOPSIS methods to rank the Cement companies listed in Tehran Stock Exchange. They believed that accurate values cannot be presented through the mere use of DEA method. Therefore, they applied a combination of methods in order to rank the companies in cement industry. Five year average values of the return on capitals and earning per share were applied as output variables, price-earnings ratio and the five-year results of productivity standards were considered as DEA inputs [15]. Azar, Anvari Rostami and Rostami (2007) applied different DEA models in order to assess the effects of investment in Information Technology on the efficiency of listed companies in Tehran Stock Exchange. Results indicated that DEA models are suitable to rank and evaluate the efficiency of decision making units. Moreover, Charnes, Cooper and Rhodes (CCR) model is more technically efficient compared to Banker, Charnes and Cooper (BCC) model [2]. Masihabadi and Vahedian (2009) investigate the efficiency of companies based on DEA technique and their debt-paying ability in date of maturity. Accuracy and validity of results achieved through DEA technique in credit ranking applying the information related to two groups of manufacturing companies listed in Tehran Stock Exchange, and seven different financial ratios were tested. Statistical results indicated that there is a significant correlation between the calculated efficiency through DEA technique and the companies' debt-paying ability in date of maturity [14]. Dadkhah et al (2010) applied Data Envelopment Analysis to measure the relative financial efficiency of ten active companies in spare parts industry, which were listed in Tehran Stock Exchange between 2002 and 2006 and investigate its relationship with stock return. Input indices included: direct materials, direct labor cost, production overhead, and distribution, sale, general and administrative, and financial costs. Gross sale and earning were the output indices. Results showed a significant relationship between relative efficiency and stock return [4]. Mahmoudi and Mattan (2011) applied Data Envelopment Analysis in order to investigate the relationship between investment return and the risk of metal industry companies listed in Tehran Stock Exchange. Operating costs, and shareholders' equity were considered as input variables. Output variables included net profit and operating cash flow. Results indicated that there is a significant relationship between the risk level and efficiency of the companies, but no significant relationship was found between investment return and efficiency [12]. In a research named "Explanation of Stock Evaluation Model in Tehran Stock Exchange through a Combination of ELECTRE and Data Envelopment Analysis Approaches" Mansuri and Nuori analyzed and ranked fifty top companies in four periods. One year Earnings per share, three-year and five-year return were considered as model output in Data Envelopment Analysis. Earnings-price ratio per share and systematic and non-systematic risks were defined as inputs [16].

In a research named "Explanation of the Effects of Risk on Efficiency of Banks Applying Efficiency Evaluation through DEA", Panahian and Abyak (2013) concluded that as the credit risk index, the defaulted credits-total credits ratio is significantly related to efficiency [17].

Method

Considering the use of existing methods and models of performance evaluation, this is an applied research. Descriptive statistical method is applied to collect data. A post-event plan is used relying on previous functional information.

Hypotheses

No specific hypothesis can be proved since the efficiency and inefficiency of the studied companies is determined through Data Envelopment Analysis.

Statistical population and sample

The statistical population includes all machinery and equipment companies listed in Tehran Stock Exchange. No sampling method is applied. Therefore, the sample under investigation also includes all active companies in Tehran Stock Exchange between 2009 and 2013, for which the required information to calculate the research variable are accessible. Considering the mentioned limitation, 15 companies fulfil this condition according to the list of Securities Organization in Research and Management Website.

Models and Variables

DEA models are divided into two groups: CCR and BCR models. Each of these models can be investigated both through input-oriented and output-oriented processes. Data Envelopment Analysis is a non-parametric method with a linear problem-solving approach designed through CCR model introduced by Charnes et al. (1978) and developed through BCR model introduced by Banker et al. (2002). This technique is a suitable method to evaluate the efficiency of units that can produce several outputs out of several inputs. The subject under investigation in DEA method that convert the inputs to outputs is called a decision-making unit. This unit might be a hospital, bank, university, store, etc. Cooper et al. (2002) indicated that decision-making units should have homogenous inputs and outputs that give a concept to their evaluation, efficiency calculation and comparison [19]. In order to calculate the efficiency of decision-making units applying Data Envelopment Analysis models, the obtained efficiency score usually falls between 0 and 1. The closer the efficiency score of the decision-making unit is to 1, the more efficient it is. The closer the efficiency score of the decision-making unit is to 0, the more inefficient it is. When the obtained efficiency score is equal to 1, the unit is considered as being efficient. Therefore, one of the most important and interesting issues in Data Envelopment Analysis, is to rank the efficient units. The most important ranking method is presented by Anderson and Peterson (1993). When the performance of organizations is evaluated through the systematic approach, three elements are mostly considered: input, output, and the conversion process. These would be investigated compared to other manufacturing units in order to determine the unit's efficiency [6]. Considering the limitations in choosing input and output variables, some of the variables would be selected through Delphi method depending on the number of decision-making units. Fixed assets, intangible assets, cost of goods sold, and general, organizational and financial costs were selected as model inputs. The selected variable as model output is the sale income.

Findings

Output-oriented BCR method (banker et al) is applied in the present research. The mentioned is implemented within a multi-stage process. Table 1 illustrates the results achieved through efficiency evaluation of the machinery and equipment active companies listed in Tehran stock exchange.

Table1: Results achieved through Data Envelopment analysis

Companies	DEA(2010)	DEA(2011)	DEA(2012)	DEA(2013)	DEA(2014)
HepCo	1/000	0/992	0/923	0/318	1/000
Aabsal	1/000	1/000	1/000	0/767	1/000
Butan	0/993	0/962	0/872	0/726	0/873
Sarma Afarin	1/000	1/000	0/949	0/807	1/000
Pars Alliance	0/875	0/880	0/869	1/000	1/000
Pars Khazar	1/000	0/942	0/901	0/723	1/000
Iran Tractor	1/000	1/000	1/000	1/000	1/000
Azmayesh	0/653	0/552	0/447	0/195	0/490
Pars Pump	0/837	0/871	0/709	0/394	0/731
Eshtad Iran	0/869	1/000	1/000	1/000	0/989
The development of industry and services, agriculture	1/000	1/000	1/000	1/000	1/000
Combine Iran	0/807	0/844	0/640	0/611	0/850
Machine Propulsion	1/000	1/000	1/000	1/000	1/000
Firouza	1/000	1/000	0/899	0/752	0/888
Tectotar	1/000	1/000	0/405	0/438	1/000

According to the findings, nine efficient companies and 6 inefficient companies have been identified in machinery and equipment industry in 2010. The number of efficient companies has decreased to 8 in 2010. In years 2012 and 2013, there has been 5 efficient companies and 11 inefficient ones. By 2014, the number of efficient companies increased to nine once more. Table 2 illustrates the average efficiency of machinery and equipment industry from 2010 to 2014.

Table 2: Average efficiency of the industry

Year	2010	2011	2012	2013	2014
Average results of DEA	0/936	0/932	0/841	0/715	0/921

Findings indicate that the average efficiency of the industry has followed a descending trend from 2010 to 2013, while it has increased in 2014.

Conclusion

One of the important issues in traditional evaluation of companies' performance is that financial ratios merely cover the financial aspect of performance. As a result, it is not easy to give an opinion about the financial health of firms. Data Envelopment Analysis technique has been introduced as a supplementary method for the traditional analysis of financial statements of the firms [11]. In this research, the efficiency of active companies in machinery and equipment industry that are listed in Tehran Stock Exchange is evaluated through Data Envelopment Analysis. According to the results, there were 9 efficient companies and 6 inefficient ones in 2010. The number of inefficient companies increased within the next year and this trend continued up to 2013. By 2014, companies could decrease the consumption of resource under the title of cost of goods sold, operating, financial and general coats, and fixed assets. As a result a higher sale income was achieved compared to the two past years. There for the number of efficient companies increased to 9 once more. During the investigation period, only three companies including Iran Tractor Industrial Group, Agricultural Industries and Services Development Corporation and Niroumoharekeh Machin was able to work efficiently. Results also indicates that by and large, machinery and equipment industry has been inefficient during these five years. Considering the significance of environmental and general condition of the country in economic, political and social aspects, as the foundation of industrial success and development, the change in this condition can be one of the reasons of the increase in efficiency of companies in 2014. The important matter is that such actions are not taken automatically, but the state has to play an effective role.

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