Journal of Applied Research on Industrial Engineering

Journal of Applied Research on Industrial Engineering

Vol. 1, No. 2 (2014) 59-73

Journal of
Applied Research on Industrial Engineering

Ranking Organizations On The Basis of Intellectual Capital Indices By Applying DEA: A Case Study of Petrochemical Companies Listed On Tehran Stock Exchange

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ARTICLE INFO

Article history :
Received:
5 June 2014
Received in revised format:
11 July 2014
Accepted:
20 July 2014
Available online:
10 August 2014

Keywords :
ranking, Data Envelopment Analysis (DEA), Intellectual Capital, petrochemical companies, Stock Exchange

ABSTRACT

DEA (Data Envelopment Analysis) is a linear programming method whose main purpose is comparing and evaluating a number of similar decision making units with different amounts of input and output. Using this method, one can rank efficient and inefficient companies and then among the efficient companies, identify the efficiency frontier. In ranking stock companies, one of the factors which have been overlooked in previous research is "Intellectual Capital" index. In this paper, based on this index, along with financial indices, the petrochemical companies listed on the stock exchange have been ranked by means of Data Envelopment Analysis method and then efficient and inefficient companies have been identified. Subsequently, employing Benchmark Approach, efficient units have been ranked. Also, to determine the importance of inputs, by applying Sensitivity Analysis, the model has been solved three times, each time removing one of the inputs and the difference between the obtained values and the values gotten from the primal model has been calculated. The results of the study show that among the 16 companies under study, 9 units have been known to be efficient and the "Intellectual Capital" index, as an input in DEA model, has a significant role in evaluating these units.

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1. Introduction

One of the important issues for the investor knows how to invest in the stock market and one criterion which can help the investor to decide to invest in the stock market, is the performance of a certain company. In the traditional view, the main purpose of evaluation is assessing and reminding the performance whereas in modern view, the philosophy of evaluation is focused on the growth, development, and improvement of the capacity of the thing being evaluated.

Therefore, evaluating the performance of a company can not only give guidelines to the investor, but also may be very helpful to the organization or company which receives the investment. If an organization's objective is to increase its shareholders' wealth, it should have a performance evaluation criterion which is consistent with the creation of value in the long term (Noravesh and Heidari, 2005). By using the results of performance evaluation and company rankings, one can identify the strengths and weaknesses of the performance and external opportunities and threats. There are many different methods for ranking, most of which are based on a major index. For instance, companies may be classified on the basis of their sales or revenue. The main problem with these methods is that they do not characterize the top companies but may identify the largest or most massive ones (Ghodtarian Kashan and Anvari Rostami, 2005). However, the performance of the company is a criterion that can encompass a lot of other indices. Therefore, ranking companies based on evaluating their performance is a much more comprehensive method compared to other one-index methods. Among the advantages of ranking based on the performance, we can mention the possibility of comparing the company with competitors, identifying the internal strengths and weaknesses and environmental opportunities and threats to help formulate strategies that correspond to the environment and company potentials, improvement, guidance, and direction of senior managers of the company and its different units based on the evaluations, reconsidering the previous investments and making decisions about the new investments based on the company rankings which have been calculated on the basis of performance assessment, helping the credit providers with selecting the top companies for granting future credits, rethinking and deciding on the purchase and making customers loyal to top companies, helping to revise the decisions of government and public organizations on advocacy, and intervention, punishment, encouragement and guidance of companies.

In industrialized countries, concerning the prioritization of stock companies in which the investor's activities facilitates decision making, some companies named consulting companies and ranking stock companies have come into existence. Thus, with regard to the economic conditions in Iran and movement towards privatization, a method or framework ought to be formed to facilitate the investor's activities in the stock market.

Among different types of companies, stock companies have been given a great deal of attention because their shares are presented in a market called stock market. A stock company is a company in which the company's investment is divided into equal parts called shares which are the main source of financing in the company. According to the Commercial Code of Iran, stock companies are divided into two types: Private Joint Stock Company (with at least 3 shareholders) and Public Joint Stock Company (with at least 5 shareholders). Each of these companies is subject to specific rules.

Because of the boom in stock companies, ranking them is an issue which has always been investigated in different studies. As the companies' profitability rate and financial situations are certain and common criteria for their evaluation, in this study, the companies are classified in terms of their financial position and their published financial statements (Hatami Shirkouhi et al., 2012)

One new method for assessing the performance of companies is Data Envelopment Analysis (DEA) which is a multi-criteria method for decision making and evaluating the performance of companies. In this method, using several input and output variables, we can calculate the efficiency of companies whose data are available and distinguish efficient companies from inefficient ones. In addition, we can ascertain the reason of inefficiency of companies by applying Sensitivity Analysis (Khajavi et al. 2005)

According to the research conducted by Sarmadi (2013), there is a significant relationship between Intellectual capital and two performance indices (return on shareholders' equity and return on sale) in petrochemical companies listed on Tehran Stock Exchange.

With regard to the above argument over the requirement of ranking on the basis of performance evaluation, this research first attempts to formulate the ranking indices and then by adopting Data Envelopment Analysis, investigates the performance of petrochemical companies which are listed on the Stock Exchange. Afterwards, based on the determined indices, this research will rank the companies. One advantage of this study which has not been considered in similar studies, is taking account of the "Intellectual Capital" variable as an input variable in the model. In this research, first and foremost, by regarding "Intellectual Capital Index", "current costs of the company" and "current liabilities" as inputs and "Earnings per Share", "Gross Income per Share" as outputs, we rank the petrochemical companies listed on the Stock Exchange and based on the rankings, we identify efficient and inefficient companies. Then, in the second phase of the study, adopting Benchmark Approach, we rank the units which have been obtained efficient. In the next phase, in order to identify the importance of inputs and obtain practical results in this study, we will solve the model each time by removing one of the inputs and will obtain the difference between the objective function of the new model and the main model.

With regard to the role of decision making in investment, this ranking could help the investors to choose the top companies. Furthermore, by identifying companies which have been given lower rankings, the previously mentioned ranking can help these companies to reconsider their formulated strategies.

2. Review of Literature

The evaluation of company performance has always been an imperative issue. Many studies have been carried out on the practicality of Data Envelopment Analysis (DEA) for evaluating companies. In their study, Azar et al. (2007) have utilized Data Envelopment Analysis so as to assess the impacts of investment in information technology on the efficiency of the present companies in Tehran Stock Exchange. The obtained results of their study indicate that the DEA models are appropriate models for ranking and evaluating the efficiency of decision making units. In addition, Charnes – Cooper – Rhodes model (CCR) has been technically more efficient than Banker – Charnes – Cooper model.

Applying a nonparametric approach, in their study, Khajavi et al. (2005), have first divided the investment companies into two categories of efficient and inefficient and by using (A & P) , (CEM), and (DEA/ AHP) methods , have subsequently ranked the efficient companies.

Anvari Rostami and Khotanlou (2006) conducted a comparative study in which two conventional methods were explored. In their research, the method of company rankings on the basis of distinctive indices of Tehran Stock Exchange was compared to the method of accounting profitability ratios such as gross profit ratio, operating profitability ratio, and return on shareholder's equity, etc. The research findings suggest that there is a little correlation between these two groups of ratings and therefore, the top companies selected by the Stock Exchange do not necessarily have a higher rank in terms of profitability ratios.

Chang et al. (2007) utilized the Data Envelopment Analysis (DEA) as a different method for credit rankings of the companies. They first describe the method and explain the way to use it as an appropriate method for credit ranking. The numerical examples in their research show that the DEA approach has sufficient potential for credit rankings of business entity.

Wang et al. (2005), provide a new technique for solving Interval DEA models and also a new method for ranking and finding efficient and inefficient decision making units. The results of their research reveal that solutions obtained through this model, are very close to the solutions of the Interval DEA model, are less complicated, and require less time to be solved. Also, the Interval DEA method is an appropriate method for measuring the efficiency of decision making units in uncertain conditions.

Souza and Miranda (2003) employed an output-oriented DEA model to evaluate the efficiency of banks in Brazil. The results obtained from their study indicate the relationship between the efficiency of banks and the risk of their bankruptcy.

Cooper et al. (2001) presented a method for determining the efficiency of decision making units and established a mechanism for imprecise data such as interval and fuzzy data. The findings of their research show that for determining the efficiency of real world problems, the foregoing method provided more accurate results than the classical DEA model.

Khajavi et al. (2005) have used DEA to offer a portfolio of the most efficient companies which are listed on Tehran Stock Exchange. In their article, they have employed a CCR model which is input oriented and has an envelopment form. The results showed that among the 90 companies under investigation, 29 companies which in fact comprised 32% of all companies were efficient and the other 61 companies were known to be inefficient.

Salehi Sadeghiani et al. (2008) attempted to evaluate the relative efficiency of business organizations by adopting the output-oriented BCC model with modified values. As for the final ranking, the inefficient units were ranked with regard to the scores obtained through DEA model and the efficient organizations were examined and analyzed by means of a combination of Analytic Hierarchy Process (AHP) and Data Envelopment Analysis (DEA). The most significant outcome of their study is identification of efficient units and the possibility of strategic planning and goal setting by means of model answer.

To assess the efficiency of petrochemical companies in Tehran Stock Exchange, a research has been carried out by Ranjbar et al. (2013). In order to calculate the efficiency of companies that have been active in Stock Exchange in the years 2003-2010, the researchers have employed a dynamic

Data Envelopment Analysis (Window Analysis). The findings of their study reveal that among the companies under investigation, six companies are 80% more efficient.

3. Model Selection

Considering the fact that most ranking methods emphasize on a main index, ranking on the basis of performance enjoys some advantages that other methods do not. Most utilized models for measuring efficiency and performance variables are statistical and have drawbacks such as constraints on the choice of inputs and outputs, and other disadvantages like the gap between the inputs. Yet, Data Envelopment Analysis does not have these limitations and drawbacks because it is a mathematical and non-parametric model which is not based on statistical techniques (Azar and Rostamie, 2007), and apart from a few papers (Sabeti Saleh, 2009 and Mehregan et al., 2008), in the majority of studies, all data have been considered to be absolute. The model proposed for evaluating the efficiency of petrochemical companies listed on Tehran Stock Exchange, is DEA model.

4. Data Envelopment Analysis

Data Envelopment Analysis is a mathematical programming approach for evaluating the efficiency of Decision Making Units (DMU) which has multiple inputs and multiple outputs. Measuring efficiency because of its importance in assessing the performance of a company has always been a matter of concern for researchers. In 1957, using the same method of measuring efficiency for engineering topics, Farrell measured efficiency for production units. The case which Farrel took into consideration for measurement comprised an input and an output. Charnes, Cooper, and Rhodes developed Farrell's perspective and presented a model that was capable of measuring the efficiency with multiple inputs and outputs. This model, known as "Data Envelopment Analysis" was first employed in Edward Rhode's Ph.D. thesis supervised by Cooper in Carnegie University. Rhode's thesis was entitled "Assessment of Educational Progress of Students in National Schools of the U.S. in 1976" (Mehregan, 2008). Since the model was presented by Charnes, Cooper, and Rhodes, it was known as CCR model and in 1978 was presented in an article entitled "Measuring the Efficiency of Decision Making Units" (Charnes et al., 1978).

4.1. Two Fundamental Characteristics of DEA Model

To employ Data Envelopment Analysis model for evaluating the units relatively, we need to determine two fundamental characteristics, nature of the model, and returns to scale, each of which will be elaborated below:

4.1.1. The Nature of the Model

A. The input nature (perspective): If by keeping the level of outputs constant in the process of evaluation, we try to minimize the inputs, we will have an input oriented model.

B. The output nature (perspective): If by keeping the level of inputs constant in the process of evaluation, we try to raise the output levels, we have an output oriented model.

In DEA with input perspective, we seek to obtain technical deficiency as a ratio which should be reduced in inputs so that the outputs can remain constant and unchanging and the unit can reach the efficiency frontier.

In CCR model, the values obtained for the efficiency are equal in both perspectives, but in BCC model, the values are different. The reason for selecting perspective for a model (DEA) in relative evaluation of unit performances is that in some cases unit management has no control over output amount and its amount is predetermined and constant. Like power plants, in such cases the amount of input is considered to be the decision variable. Therefore, the input perspective is employed. Conversely, in some cases, the amount of input is fixed and predetermined and the amount of production (output) is the decision variable. In such circumstances, it is appropriate to use the output perspective. Finally, the selection of input or output orientation (perspective) is determined on the basis of the manager's control on each input and output (Coelli et al., 2005).

4.1.2. Model Return to Scale

Return to scale suggests a link between input and output changes in a system. One of the capabilities of DEA model is using different models corresponding to different returns to scale and also measuring returns to scale of the units.

A. Constant returns to scale: Constant returns to scale means that each multiple of input produces the same multiple of output. The CCR model, assumes that returns to scale of the units is constant. Hence, small and large units are compared to each other.
B. Variable returns to scale: Variable returns to scale means that each multiple of input can produce the same or less or more multiple of outputs in the outputs. The BCC model assumes that returns to scale is variable (Banker et al., 1984).

4.2. Different Types of DEA Model

DEA models generally include: CCR model, BCC model and collective models. In this article, we use the BCC model which is output-oriented.

4.2.1. The BCC Model:

The BCC model which is used in this article is a mathematical form as follows (Banker and Thrall, 1992).

In DEA the multiplier form dual always results in an envelopment form. If we write dual form of multiples of CCR, the envelopment form of CCR is obtained as follows:

$$\max E_0 = \sum_{r=1}^{s} W_r O_{r0} + W_B$$

$$st: \sum_{i=1}^{m} V_i I_{i0} = 1$$

$$\sum_{r=1}^{s} W_r O_{rj} - \sum_{i=1}^{m} V_i I_{ij} + W_B \le 0$$

$$W_r \ge 0$$

$$V_i \ge 0$$

$$W_B : free$$

This model is called "Multiple BCC-I".

5. Intellectual Capital

Intellectual capital is a process that involves applied testing, organizational technology, communication with customers, and professional skills. It increases the competitiveness of the company and its future profitability (Edvinsson and Malone, 1997).

Ross et al. (1997), remark that Intellectual Capital is the main factor for creating value in companies and that, companies are moving towards creating values through intellectual assets within the company. As a matter of fact, the previous view of managers on creating values in a company by physical and financial assets has changed.

According to different definitions of Intellectual Capital, most models consider three components for Intellectual Capital, including Human Capital, Relational Capital (Customer Capital), and Structural (Institutional Capital).

Human Capital refers to the value of knowledge, skill, experience, and expertise of the employees.

Relational Capital (Customer Capital) is the sum of assets that cause the relationship with the environment, customers, shareholders, product suppliers, competitors, and the government.

Structural Capital (Institutional Capital) consists of relationships, organizational directors, etc. (Edvinsson and Malone, 1997).

The value added intellectual coefficient method which was formulated by Palic is an analytical tool for measuring the performance of the company. Value added intellectual coefficient is based on the principle that creating value is derived from two primary factors called physical capital resources and intellectual capital resources. In fact, this coefficient reflects the absolute efficiency of value creation related to all employed resources (Pulic, 2004).

In Palic's model, value added intellectual coefficient has three subsets of Human Capital Efficiency, Structural Capital Efficiency, and Capital Employed Efficiency.

A. Human Capital Efficiency (HCE)

This ratio reflects the added value created by employees. It is obtained through dividing the added value by the cost of employees' salaries and wages and shows that for every Rial of salary and wage, several Rials of added value have been created.

$$HCE = \frac{VA}{HC}$$

HC: Human Capital which is equal to the cost of employees' salaries and wages.

B. Structural Capital Efficiency (SCE)

This ratio indicated the added value which is created as a result of available processes and structures within the company and is obtained through dividing the Structural Capital by the added value.

$$SCE = \frac{SC}{VA}$$

SC: Structural Capital which is obtained through the equation below:

$$SC = VA - HC$$

C. Capital Employed Efficiency (CEE):

This ratio reveals the added value created as a result of applying physical and tangible assets. That is, for every Rial of asset, several Rials of added value have been created. This ratio is obtained through dividing the added value by the Capital Employed.

$$CEE = \frac{VA}{CE}$$

CE: Capital Employed, which is equal to the book value of the total assets of the company excluding intangible assets. Therefore, Palic's value added intellectual coefficient is obtained through the following equation:

$$VAIC = HCE + SCE + CEE$$

In Palic's model, the Relational Capital (Customer Capital) is not taken into consideration.

Considering the model utilized and the theoretical principles of Palic's model, the components of Intellectual Capital were used as dependent variables which include: Capital Employed Efficiency (CEE), Structural Capital Efficiency (SCE), and Human Capital Efficiency (HCE) (Khanhossini, 2012).

6. Methodology

One of the most common financial criteria for evaluating the performance of companies is analyzing financial statements, financial ratios, profit margins, etc. Nikoumaram et al. (2005) regard

the financial assessment criteria for evaluating the performance of companies as inefficient and consider the rankings which are based on these criteria to be invalid. They state that these criteria only reflect a one-year short-term performance, do not consider strategic plans and objectives, do not have the capability to calculate the efficiency of a business entity with regard to both qualitative and quantitative criteria, are incapable of ranking homogenized business entities in an industry, and are not able to present solutions for the improvement of efficiency. Considering the drawbacks stated above, in their study, Nikoumaram et al. (2005) provided a comprehensive system of evaluation and performance measurement for the investment companies which are listed on Tehran Stock Exchange. In order to achieve their research goals and objectives, they also employed Data Envelopment Analysis and regarded the company's current costs and current liabilities as inputs and returns per share and gross income per share as outputs. However, Sarmadi (2013) has investigated the relationship between the Intellectual Capital and the companies' profitable indices in the period between 2008-2012. The findings of her study show that in petrochemical companies listed on Tehran Stock Exchange, there is a significant relationship between Intellectual Capital and two performance indices (returns on equity and returns on sale).

In the next part, the proposed model will be applied for our case study, Petrochemical Companies Listed on Tehran Stock Exchange. We first specify the input and output indices for DEA model. Then, the DEA model will be solved by DEA solver software and the results will be determined. Next, in order to clarify the importance of each input index, the model will be resolved 3 times with omission of per input each time.

7. Case Study and Findings

In this section, we apply the proposed DEA model for "Petrochemical Companies Listed on Tehran Stock Exchange ".

7.1. Input and Output Indices

Regarding to the issues discussed above, and the importance of the Intellectual Capital Index in the performance of companies, according to Table 1, "Intellectual Capital Index" ,"the company's currents costs", and "current liabilities" are considered to be the inputs, and "returns on per share" and "Earnings per share(EPS)" are regarded as outputs in the model of this research.

Table 1 The input and output variables in DEA model

Symbol	Input index	Symbol	Output index
I_1	Intellectual Capital Index	O_1	Return on per share
I_2	Current Costs	O_2	Earnings per share(EPS)
I_3	Current liabilities		

The input and output values of the model can be observed as a normalized form in Table 2.

Table 2 The Input and Output Values in DEA Mode

Petrochemical company symbol	Inputs			Output	
	Intellectual Capital	Current Costs	Current Debts	Return on per share	Earnings per share(EPS)
PRDZ1	0.78	0.11	0.04	0.82	0.30
PSHZ1	0.09	0.20	0.14	0.87	0.10
PFRB1	0.19	0.01	0.01	0.86	0.20
PKHA1	0.07	0.27	0.31	0.78	0.39
PKER1	0.20	0.08	0.11	0.79	0.03
PMRZ1	0.29	0.80	0.24	0.77	0.16
PFAN1	0.10	0.20	0.15	0.81	0.33
PZGZ1	0.07	0.21	1.00	0.83	0.27
IPTP1	1.00	0.26	0.08	0.81	0.02
PAKS1	0.12	0.05	0.04	0.81	0.35
SSIN1	0.18	0.11	0.06	0.83	1.00
PARK1	0.07	0.32	0.20	0.82	0.22
PABD1	0.15	0.04	0.01	0.81	0.04
PKBP1	0.10	0.24	0.17	0.81	0.04
PJMZ1	0.15	1.00	0.63	0.87	0.14
PSKZ1	0.18	0.08	0.04	0.81	0.10

7.2. Solving DEA Model

In order to solve the model, in this article we use output orientation BCC model. The output of the model solution is shown in Table 3.

Table 3 The Results of Model Solution

DMU No.	DMU Name	Efficiency
1	PRDZ1	1.04083
2	PSHZ1	1.00000
3	PFRB1	1.00000
4	PKHA1	1.00000
5	PKER1	1.09136
6	PMRZ1	1.12335

Table 3 The Results of Model Solution

DMU No.	DMU Name	Efficiency
7	PFAN1	1.00923
8	PZGZ1	1.00000
9	IPTP1	1.06055
10	PAKS1	1.00000
11	SSIN1	1.00000
12	PARK1	1.00000
13	PABD1	1.00000
14	PKBP1	1.06500
15	PJMZ1	1.00000
16	PSKZ1	1.06261

As can been seen, the following petrochemical companies have reached efficiency: The Petrochemical Company of Shiraz, Farabi, Khark, Zagros, Paxan, Iran Chemical Industry Investment, and Shazand (Arak), Abadan, and Jam Petrochemical companies.

7.3. An Investigation of the Importance of Input Indices

Now, in order to evaluate the impact of each input in the model, each time one of the inputs is removed and the model is re-solved. Eventually, the results are shown in Table 4. The first column of the table indicates the units under study and the second column shows the results of solving the initial model. In columns 3 to 5, the results of solving the model after removing each input are given and columns 6 to 8 show the difference between the results and the primal model.

Table 4 A Comparison of Input Removal Model with the Primal Model

Petrochemical company symbol	Basic Model	1th input omission	2nd input omission	3rd input omission	Difference with basic model		
PRDZ1	1.04083	1.04083	1.04083	1.04200	0.00000	0.00000	0.00117
PSHZ1	1.00000	1.00000	1.00000	1.00000	0.00000	0.00000	0.00000
PFRB1	1.00000	1.00000	1.00000	1.00000	0.00000	0.00000	0.00000
PKHA1	1.00000	1.08725	1.00000	1.00000	0.08725	0.00000	0.00000
PKER1	1.09136	1.09136	1.09606	1.09136	0.00000	0.00470	0.00000
PMRZ1	1.12335	1.12335	1.12335	1.12449	0.00000	0.00000	0.00115
PFAN1	1.00923	1.05276	1.02887	1.03396	0.04352	0.01964	0.02473
PZGZ1	1.00000	1.04050	1.00000	1.00000	0.04050	0.00000	0.00000

Table 4 A Comparison of Input Removal Model with the Primal Model

Petrochemical company symbol	Basic Model	1th input omission	2nd input omission	3rd input omission	Difference with basic model		
IPTP1	1.06055	1.06055	1.06055	1.06500	0.00000	0.00000	0.00445
PAKS1	1.00000	1.04832	1.00000	1.00000	0.04832	0.00000	0.00000
SSIN1	1.00000	1.00000	1.00000	1.00000	0.00000	0.00000	0.00000
PARK1	1.00000	1.04838	1.00000	1.00000	0.04838	0.00000	0.00000
PABD1	1.00000	1.05518	1.00000	1.02337	0.05518	0.00000	0.02337
PKBP1	1.06500	1.06500	1.06500	1.06500	0.00000	0.00000	0.00000
PJMZ1	1.00000	1.00000	1.00000	1.00000	0.00000	0.00000	0.00000
PSKZ1	1.06261	1.06261	1.06261	1.06369	0.00000	0.00000	0.00108
Sum					0.32315	0.02434	0.05595

As shown in Table 4, removing the first input (Intellectual Capital) causes the biggest difference with the primal model. In other words, the Intellectual Capital Index has an important role in the evaluation of decision making units.

8. Conclusion

One of the important issues for the investor knows how to invest in the stock market and one criterion which can help the investor to decide to invest in the stock market, is the performance of a certain company. One new method for assessing the performance of companies is Data Envelopment Analysis (DEA) which is a multi-criteria method for decision making and evaluating the performance of companies. In this method, using several input and output variables, we can calculate the efficiency of companies whose data are available and distinguish efficient companies from inefficient ones. In addition, we can ascertain the reason of inefficiency of companies by applying Sensitivity Analysis.

In this research, after formulating the ranking indices, by means of Data Envelopment Analysis, the performance of petrochemical companies listed on Tehran Stock Exchange were investigated and then on the basis of predetermined indices the companies were ranked. One advantage of this study which has not been considered in similar studies, is taking account of the "Intellectual Capital" variable as an input variable in the model. First and foremost, by regarding "Intellectual Capital Index", "current costs of the company" and "current liabilities" as inputs and "Earnings Per Share", "Gross income Per Share" as outputs, we ranked the petrochemical companies listed on the Stock Exchange and based on the rankings, we identified efficient and inefficient companies. Then, in the second phase of the study, adopting Benchmark Approach, we ranked the units which had been obtained efficient. In the next phase, in order to identify the importance of inputs and obtain practical results in this study, we solved the model each time by removing one of the inputs and obtained the difference between the objective function of the new model and the primal model.

As shown in Table 4, removing the first input (Intellectual Capital) results in the biggest difference with the primal model. In other words, the Intellectual Capital Index has an important role in the evaluation of decision making units.

With regard to the role of decision making in investment, this ranking could help the investors to choose the top companies. Furthermore, by identifying companies which have been given lower rankings, the previously mentioned ranking can help these companies to reconsider their formulated strategies.

9. Research limitations

In this paper, we gathered the required data from "Tehran Securities Exchange Technology Management Co. (TSETMC)" website. As the audited information for all petrochemical companies are not complete, we were forced to study companies on the basis of a six month period. So, the ranking results can be discussed for that period.

10. Future study

In order to get more precise results, we used output orientation BCC model in this paper. But other DEA models can also be applied for solving the model and be comprised with the model of this paper. Moreover, the model proposed in this paper could be applied for ranking any other companies which have similar accessible data.

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