International Journal of Finance, Accounting and Economics Studies, 3(2), 2022, 1-14.
Print ISSN: 2251-645X Online ISSN: 2383-2517

Islamic Azad University
Science and Research Branch
Faculty of Management and Economics

International Journal of Finance, Accounting and Economics Studies
Journal Homepage: https://ijfaes.srbiau.ac.ir

Evaluating the Performance of Companies Listed in Tehran Stock Exchange based on Financial Ratios Using DEA (The Case of Chemical & Medical Company)

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Article History
Submission Date: 2022-05-04
Revised Date: 2022-07-27
Accepted Date: 2022-09-03
Available Online: 2022-11-09

JEL Classification:

Keyword:
Performance Evaluation
Financial Ratios
Tehran Stock Exchange
DEA Technique
Chemical & Medical Companies

Abstract
Today determining the portfolio of investments is one of the most important issues in investment management. Therefore, the most important problems of the proposed models is the lack of consideration of multiple indicators and criteria in evaluating the performance of the stock portfolio. Many Chemical & Medical companies embark on process improvement initiatives, but lack evidence that these programs result in high efficiency. Therefore, the purpose of this study is to examine the performance of chemical companies listed in Tehran Stock. The study uses Data Envelopment Analysis (DEA) to understand Chemical co. efficiency and effectiveness. To measure the performance of companies, the total assets, equity, and ADS was used as inputs and outputs consist of NPM, ROE, and ROA. In the course of this research, formulation of hypotheses and systematic removal of 32 companies by stock exchange, the 5-year period 2012- 2017 were selected with reference to their financial statements, the information necessary to measure the variables, extraction and statistical tests on they were carried out. The results of the DEA indicate the existence of different degrees of financial ratios in Medical and Chemical Companies. When by Anderson Peterson model, companies can be ranked and categorized into three groups: strangely super-efficient, supper-efficient and efficient. Data envelopment analysis technique turned different ratios and financial data into a unit and comparable measure called "efficiency". Therefore, it can suggested that data envelopment analysis technique can be a reasonable complement to traditional analysis of financial statements using financial ratios.

[*] Paper presented at the 15th International Conference on Data Envelopment Analysis in the DEA Conference to held at University of Economics, Prague in the Czech Republic, on June 26 to 29, 2017.

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1. Introduction

Many studies have been conducted to achieve a proper criterion to assess the performance of companies and managers in order to ensure the consistency of a company with the interests of the actual investors and make a basis to make economic decisions of potential investors and creditors. The results obtained from these studies have provided four approaches in relation to the performance criteria [1]. These consist four approaches- The accounting approach [2], the economic approach, the integrated approach, the financial management approach [3]. Among several performance assessment approaches, Data Envelopment Analysis (DEA) has become one of the crucial tools that have been commonly adopted to financially evaluate firms in various fields [4,5]. In a general classification, the criteria of measuring performance can be divided into two groups of financial and non-financial criteria. Non-financial criteria include the criteria for the production, marketing, administration and social criteria and financial ratios are the techniques that have been suggested as financial criteria. Some finance researchers have suggested that composite indices (financial and non-financial) should be used. However, this is difficult because determining the type of the criteria and their correlation as well as determining the value and weight of each of them as a total is not a simple task [2, 6].

The financial ratios indicate the strength or weakness of the companies compared with other companies in the same industry, leading companies and last year's performance of the same company [7]. Financial ratios are calculated simply, while their interpretation is often difficult and controversial, especially when two or more ratios show the conflicting signs to each. The main problem of the financial statements' ratio analysis is that each of financial ratios assess one aspect of the financial performance of an organization so that a group assesses the ability of liquidity, a group assesses profitability, another part assesses the ability to grow and finally the last group assesses on the practice of organization's operation [8].

Although the importance of organizational performance is widely known, but there is a significant discussion about technical and conceptual issues of the performance measurement. Measure the performance individually and as is clear from all directions is not possible. The organization's performance is a wide combination of intangible earnings, such as increasing the organizational knowledge and objective and tangible receipts, such as the economic and financial results. Among objective indices of organizational performance, profitability indices such as return on asset, return on equity, return on investment, return on equity and earnings per share can be noted. The indices are also traditional indices of the performance. Subjective criteria of organizational performance include the indices that are formed based on the judgment of the beneficiary groups [9]. One of the effective methods to evaluate the efficiency of different decision-making units (DMUs) is DEA, since DEA is a nonparametric method which accounts for qualitative and quantitative measures and transfers multiple inputs into multiple outputs [10]. DEA models can be classified into two categories: radial and non-radial. Radial models include traditional CCR and BCC models. A DEA model with log-transformed input and output values that allow for both increasing and decreasing marginal products These models can be regarded as either input or output oriented [11, 12].

Non-radial models encompass alternative modelling specifications, such as the additive model, the multiplication model, the range-adjusted measure and the slacks-based measure. This efficiency

estimation technique can be used for solving many problems of management such as ranking of DMUs and evaluating CRM policy [13]. DEA is a powerful model for ranking and evaluating DMUs, but, there is a drawback to this model. DEA model considers DMUs as a black box that get inputs and changes them to the output, while the internal linking activities in the DMUs are neglected [14, 15]. Financial theorists [16, 17, and 18] have proven the need for measurements of non-financial performance that drive success in achieving strategic goals. In this regard, advanced production methods have been used for the performance consequences of non-financial measurements in companies [19]. However, the question is why financial measurements are usually more objective and less dependent on managerial mentality, and non-financial measurements are usually related to key strategic factors. Therefore, the selection of performance measurements is one of the most important issues in the design of control systems. In order to answer whether only traditional financial indicators are suitable for monitoring the performance of companies or not, data envelopment analysis has been used to solve this problem in research [20]. Data envelopment analysis technique for non-financial and financial measurements as input / output variables provides a criterion for measuring the performance of industry and companies. In particular, many studies have used data envelopment analysis technique to measure industry performance [21, 22].

The present study proposes the data envelopment analysis technique method to solve this problem is. This method with ratios' aggregation allocates a single score named "efficiency" to each studied unit. In fact, this technique by entering ratios as the model input and output turns them to a single criterion that increases the ability to assess and compare the performance. Tehran Stock Exchange is one of the most influential organizations on the development of decision-making, policy-making, decision-making, production, and support of manufacturers. Therefore, a study for the assessment of the listed companies in it is very important. Hence, the question rises that how is the efficiency of pharmaceutical and chemical companies listed in the Tehran Stock Exchange in terms of DEA technique?

2. Theoretical framework

DEA is one of the popular and applicable techniques for assessing and ranking the stocks or other financial assets. It should be noted that in the financial markets, most of the times, the inputs and outputs of DEA models are accompanied by uncertainty [23]. The main key to achieve the goal is to assess the performance. An efficient assessment system to identify the executive strengths and weaknesses is the current status of the organizations and the realization of programs and achieving goals required [24]. Control and performance measurement systems are official information-based procedures and matters that are used by managers to protect and reform the organization's activities. One of the reasons of the failure of managers' efforts who are interested in improving their organization's financial performance is the lack of an appropriate tool to assess the performance of organizations. A set of new economic conditions, existing changes in the new patterns of management and administration of the organizations and the inefficiency of traditional methods of assessment have created the need for the change and development of the criteria for measuring the financial performance, the profitability of a unit is closely related to the amount of investment and none of the traditional methods pay attention to the amount invested. A summary of views of some researchers in the field of the limitations of

traditional profit-based criteria [25, 26, 27] including; (1) The ability to manipulate a lot due to the commitment of using different accounting methods and different use of standards (2) Relying on the limiting principles and methods such as the principle of conservatism and accrual method (3) The lack of a prospective vision and ignoring the factors such as the advances in the technology and new production technologies, the innovation of new products, the time value of money and etc. (4) Inattention to the value creation factors such as the intellectual capital and intangible asset (5) Inattention to the actions of the cost of financing through the equity [28].

Melnyk et al. [29] shows that the criteria and measurements of the performance are obtained from the high attention to the last years, but according to Evans' [30] opinion the analysts for the analysis of the performance results in terms of competitive comparison and criteria among companies active at the industry level in the capital market need a more efficient method. On the other hand, it has been reported that the criteria based on financial indices when used in a dynamic environment to assess the business and industry performance have disadvantages as well [31]. Among the models, several model have been tested that according to the research conducted in other world stock markets have the most efficiency. These models include: Gordon, two-stage dividend discount, the discounted free cash flow payable to shareholders, adjusted present value, the price to earnings ratio and the discount model of Residual Income [32, 33]. Also, Melnyk et al. [29] in another classification performance assessment criteria are divided into five different approaches applied as follows: DEA, hierarchical process, gray relationships' analysis, balanced scorecard and the analysis of financial statements [34].To measure the efficiency of decision-making units (DMUs), Data Envelopment Analysis (DEA) is often used. Charnes, Cooper, and Rhodes [35] introduced it more than 40 years ago when they developed their CCR model, which remodeled the fractional linear measure of efficiency into linear programming.

DEA is a mathematical programming model to assess the efficiency of decision-making units that have multiple inputs and outputs. Karaman et al. [36] pointed out, using data envelopment analysis model to assess the units relatively needs to determine two basic characteristics, the nature of the pattern and returns to the pattern scale. (A) The nature of the input, if in the assessment process with constant output level trying to minimize the inputs is the used input pattern nature. (B) The nature of the output, if in the assessment process with constant input level, output level, trying to increase the output level, is used output pattern nature.

3. Literature review

Several research have been conducted on the function of data envelopment analysis technique based on the assessment of the efficiency of the economic units, but the relationship between this technique and financial variables of the performance assessment or in other words the performance assessment based on the financial statements and the financial performance has not been examined by the technique independently. DEA has investigated in various filed such as, performance evaluation [37], supplier selection [37], returns to scale in DEA [38] financial ratios [39, 40], stock exchange in order to analyse the performance [5, 40, 41, 42] efficiency of industries [43], investment in various sectors [44, 46, 47, 48], banks and business sectors [47, 45, 48], and etc .

Izadikhah (2022) has examined the DEA approaches for financial evaluation.

According to the study, Technical Efficiency, Financial Evaluation, Productivity Analysis, Portfolio Selection, and Financial Sustainability, have been recognized as the five functions with the most contribution [4].

Yan Ma and Han-Up Park (2021) simulated the estimation of an efficient production frontier with increasing marginal product. In this study the document was BM model outperforms the BCC model in estimating the efficiency frontier when the production function exhibits increasing marginal product. The BM model also reduces biases in the second-stage analysis of efficiency, providing additional insights that are not available from using the BCC model. Their analysis suggests that relatively small O&G companies may forego efficiency gains by not scaling up their businesses and that using the BM model is desirable when the production function is believed to exhibit increasing marginal product [11].

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Rajiv and Muktak (2021) provided a measure of organizational ability in the commercial banking industry. In this study they identify and evaluate contextual factors as determinants of the relative technical efficiency using OLS. The estimated residuals, part of bank efficiency, is considered a noisy measure of the unobserved organizational ability. The results show that the DEA + OLS model residuals are approximately normally distributed and are consistent estimates of banks' ability. They found that a one standard deviation change in organizational ability corresponds to a change in return on assets and revenues annually of 18.92% and 9.35%, respectively. The findings suggest that more (less) capable banking organizations are associated with higher (lower) contemporaneous and subsequent performance [49].

Soltani (2020) the study conducted with imprecise data envelopment analysis (IDEA) and its use in evaluating the performance of organizations based on the EFQM model. they consider uncertain and imprecise output data and implement the proposed framework in the real-world (to evaluate efficiency of organizations in performing EFQM model) ; they propose a robust optimization DEA model in which the output parameters are in form of intervals with uncertain bounds ; and use randomly a set of numbers generated for each input and output of DMUs to specify a range of Gamma in which the rankings of the DMUs occur with high probability and then compute the conformity of the rankings resulting from the mathematical model with reality [50].

Peykani et al. (2019) pointed to the stock evaluation under mixed uncertainties using Robust DEA model. In this study presented a novel Robust DEA model, which is capable to be used in the presence of discrete and continuous uncertainties Their analysis showed that the proposed new RDEA model was effective in the assessment and ranking of the stocks under different scenarios with interval values [5].

George & Tzeremes (2012) in a study entitled "Assessment of the efficiency of the industry using financial ratios: the use

of automated DEA" examined the overall analysis of ratio data / financial data in order to make a way for the units' measurement. Using automated techniques, this paper has examined the use of 23 production factors in Greece using financial data. The results showed that at the first stage of our critical analysis, we had the applications obtained on the basis of the baseline. After using automated techniques the critical analysis showed that the efficiency components have been significantly improved [51].

Mahmoudi and Metan (2011) using the technique of DEA and financial variables of the performance assessment such as return on investment and corporate risk grade in metal industries' group companies listed in the Tehran Stock Exchange, between 2003 and 2008 assessed the performance and then using multi-variable regression test attempted to examine the relationship. According to the results obtained the variable of the corporate risk grade with values resulting from DEA technique a positive relationship is shown so that the corporate risk grade is a proper criterion to predict the efficiency of the economic units and introduced as an alternative criterion [52].

Based on the researcher's studies and background, the important difference between the present studies is that, DEA technique was not used in previous studies of Chemical & Medical Companies to determine financial performance. During the analysis of DEA technique, we found that DEA creates a financial efficiency frontier and financial efficiency score is assigned to all the analyzed DMU, which can be compared to the units present in the analysis. Financial analyses provide valuable information regarding procedures, correlations, qualities, dividends, and finally corporate strengths and weaknesses and the quality of their financial positions. Corporate performance analysis can provide an insight to managers over time to know their future directions. Such type of analysis, especially if illustrates companies' strengths and weaknesses over different time periods, is useful in recognizing the past and present conditions and of vital value for future strategies. Another distinguishing feature of this research is the study method, so that the operational plan of this study has been done during the stages of recognition, design and implementation.

4. Methodology

The present study in terms of the purpose is applied and in terms of the method is a library and analytical-casual study based on DEA. The study population includes all companies listed on Tehran Stock Exchange during 2013 to 2018. Due to the widespread population size and the presence of some inconsistencies between the population members, companies with the following characteristics and conditions are considered as available population. Due to limited the population of the manufacturing companies in Tehran Stock Exchange and regarding the applied conditions, the available population is selected fully as a sample in order to get the most observations for statistical analysis.

1- The study period from 2013 to 2018, trading symbol is not out of the Stock Exchange Market board
2- Companies, during the course of the financial year should not be changed its activities.
3- The required financial information, especially the notes to the financial statements is available.
4- In all the years, fiscal year has not changed
5- Every six months at least have a deal and be active and profitable

Therefore, the number of chemical and pharmaceutical companies that have these characteristics are 32 companies.

In order to identify suitable input output combination, it is crucially essential to have a clear understanding of the process being evaluated. In addition, the purpose of the performance measurement effects not only the input output selection but also the model orientation as well. The proposed study of this paper uses three inputs and three outputs for measuring the relative efficiencies of various units. Fig. 1 shows details of the proposed study.

4.1 Model and Data

Figures Afterwards, to specify overall efficient units CCR model of DEA is used [35]. Further, to identify best performing units on their scale BCC model of DEA is used [12]. In input-based models, while the output is maintained at a given level, the input is reduced appropriately and possibly and on the contrary, in output-based models maintaining the appropriate input level the output is increased. "Additive model" is a model that simultaneously considers reduced input and increased output. Primary and secondary problems of additive model are as follows:

Primary Model: Secondary Model:

$$Min\ Z_0 = -\sum_{r=1}^{s} s_r^+ - \sum_{i=1}^{m} s_i^-$$

St:

$$\sum_{j=1}^{n} \lambda_j x_{rj} - s_r^+ = y_{r0} \qquad (r=1,2,\ldots,s)$$
$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{i0} \qquad (i=1,2,\ldots,m)$$
$$\sum_{j=1}^{n} \lambda_j = 1 \qquad (j=1,2,\ldots,n)$$
$$\lambda_j, s_r^+, s_i^- \geq 0$$

$$Max\ Y_0 = \sum_{r=1}^{s} y_{r0} u_r - \sum_{i=1}^{m} x_{i0} v_i + w$$

St:

$$\sum_{r=1}^{s} y_{rj} u_r - \sum_{i=1}^{m} x_{ij} v_i + w \qquad (j=1,2,\ldots,n)$$
$$\sum_{r=1}^{s} u_r \geq 1$$
$$\sum_{i=1}^{m} v_i \geq 1$$
$$u_r, v_i \geq 0 \qquad w \text{ Free}$$

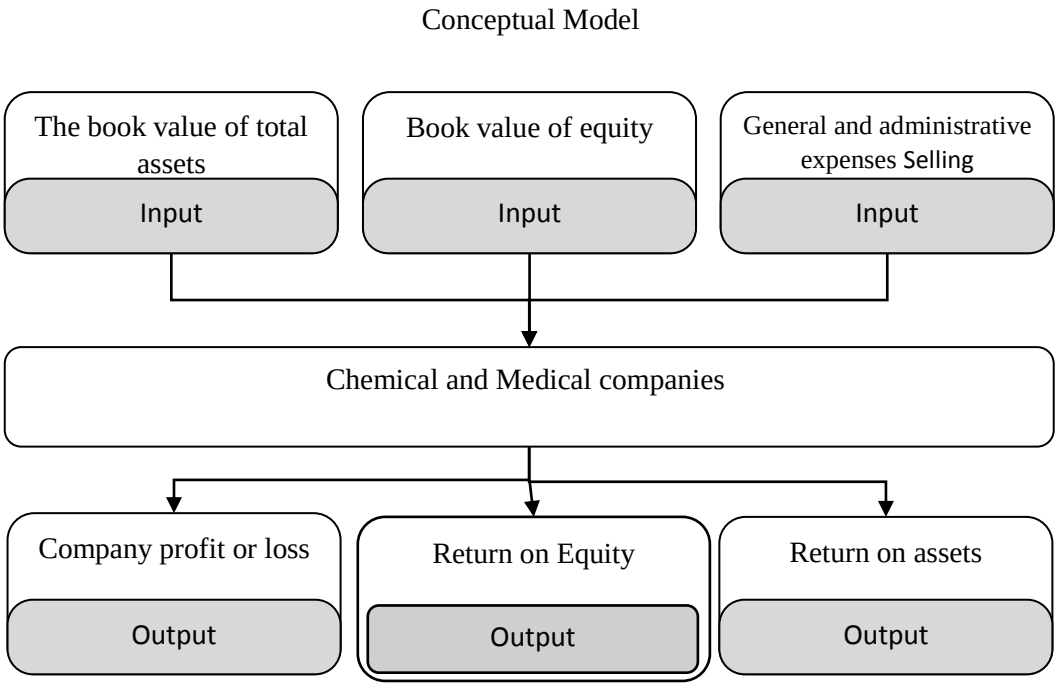

Figure1: The structure of the proposed study

The primary model is called BCC model and the secondary model is called CCR model. Note that the value 1 indicates the efficient units. If a unit efficiency is less than 1 it is inefficient. If a unit efficiency is equal to 1 and there is no output shortage and input surplus the efficiency is Pareto. If a unit efficiency is equal to 1 and there is output shortage or input surplus the efficiency is poor.

4.2 Anderson-Peterson model for ranking DMUs[1]

Anderson, and Peterson [53] proposed a method for ranking efficient units that can determine the most efficient unit. With the technique, the advantage of efficient units can be more than 1, thus efficient units also like inefficient units can be ranked. This method included 2 stages: at the 1st stage as before the efficiency is determined and after identifying the efficient units the constraint related to the efficient unit is removed from the model constraints' set until at this stage the efficiency can also be estimated more than 1.

5. Empirical Results

5.1 The statistics and data collected from the decision maker units

In this study, 32 decision-making units were examined according to 3 inputs and 3 outputs based on data envelopment analysis collectively. The data on the indices for 32 units are shown in Table 1.

In the study, a variety of descriptive statistics' parameters are expressed. In addition, the range of change based on quartiles are shown in Table 2.

Table 1: The data on the indices for 32 units

Output.3	32	.	0.2159	0.0223	0.1495	0.2049	0.0104	0.7841	0.7737	6.9081	1.7002	5.6324
Output.2	32	.	0.6006	0.0787	0.2805	0.6261	0.0354	1.3574	1.322	19.2208	0.2262	0.3795
Output.1	32	.	1782964.093	8037794871177.57	2835100.504	541576	19051	11789545	11770494	57054851	2.1553	4.315
Input.3	32	.	253295.75	1690038834.71	411100.76	108644	16878	1791283	1774405	8105464	2.9032	8.431
Input.2	32	.	3372603.9375	38747570292584.4	6224754.6371	890789.5	102891	26688683	26585792	107923326	2.7547	7.5733

[1] Decision Making Units

O	Input.1
No.	32
Missed	.
Mean	7429128.0938
Variation	10906524799989
S.D	10443491.983
Median	2748953.5
Min	253636
Max	40045220
Rang	39791584
Total	237732099
skewness	1.9527
Kurtosis	2.8151

Table 2: the range of change based on quartiles

Quarters	Output.3	Output.2	Output.1	Input.3	Input.2	Input.1
0%	0.01041113	0.035447642	19051	16878	102891	253636
25%	0.10903204275	0.426738837	189939.5	54288.75	440587.5	1786163.5
50%	0.204893105	0.6261065525	541576	108644	890789.5	2748953.5
75%	0.28990244575	0.801923855	1228909.25	211988.75	1612655	4622991.5
100%	0.784066549	1.357433974	11789545	1791283	26688683	40045220

DEA using linear programming and optimization techniques to determine the efficiency of each unit and target enhanced efficiency for each of the units determined a reference set for the inefficient unit and compare the efficiency of different units to the efficiency border.

The efficiency or inefficiency of the units are given in Table 3. Figure 1 also shows the efficient and inefficient units.

Table 3: efficient and inefficient units

Unit	Score	Performance	Unit	Score	Performance
DMU 1	0.577	Inefficient	DMU 17	0.388	Inefficient
DMU 2	0.37	Inefficient	DMU 18	0.817	Inefficient
DMU 3	0.54	Inefficient	DMU 19	0.367	Inefficient
DMU 4	1	Efficient	DMU 20	0.305	Inefficient
DMU 5	0.832	Inefficient	DMU 21	0.668	Efficient
DMU 6	0.791	Inefficient	DMU 22	1	Inefficient
DMU 7	0.499	Inefficient	DMU 23	0.481	Inefficient
DMU 8	0.662	Inefficient	DMU 24	0.815	Inefficient
DMU 9	1	Efficient	DMU 25	0.673	Inefficient
DMU 10	0.665	Inefficient	DMU 26	1	Efficient
DMU 11	0.547	Inefficient	DMU 27	0.057	Inefficient
DMU 12	1	Efficient	DMU 28	0.398	Inefficient
DMU 13	0.802	Inefficient	DMU 29	0.715	Inefficient
DMU 14	0.922	Inefficient	DMU 30	0.307	Inefficient
DMU 15	0.894	Inefficient	DMU 31	1	Efficient
DMU 16	0.714	Inefficient	DMU 32	1	Efficient

5.2 Rank an efficient unit based on Anderson-Peterson technique

Envelopment analysis basic models due to the lack of full ranks among the efficient units do not allow the comparison between the mentioned units easily. Because in these models the efficiency score 1 is allocated to all efficient decision maker units, the need for ranking the efficient

units and maintain the inefficiency of the inefficient units is inevitable. In the assessment by AP method (Anderson-Peterson) the unit examined is removed from the assessment, and in this way the number allocated to the efficient units in AP full ranking model is greater than or equal 1 as well as the efficient units are ranked. The efficiency level according to the defined model is shown in Table 4 and Fig. 3. The units with the efficiency 1 and more are super-efficient

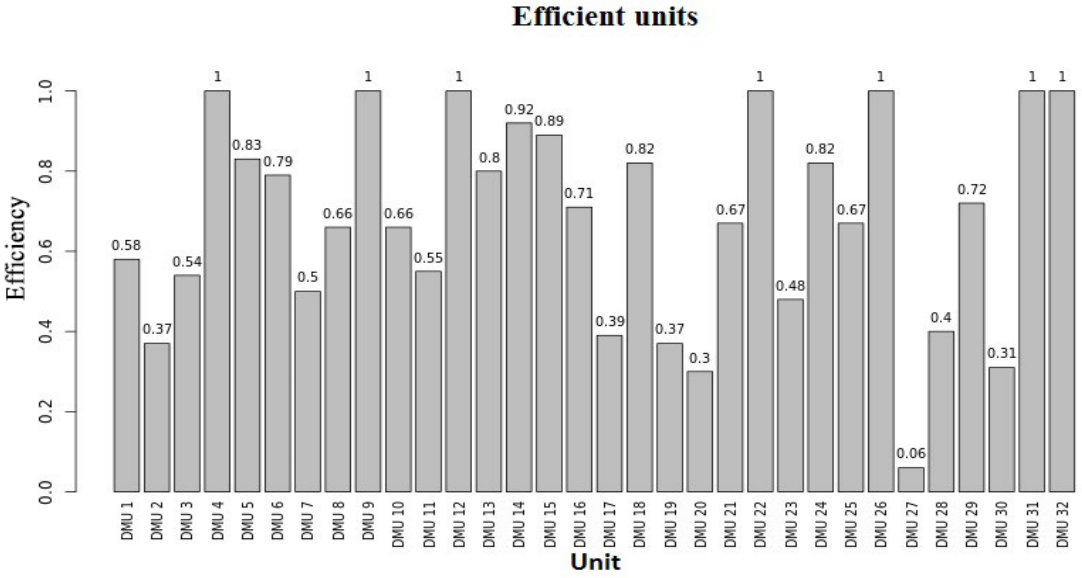

Figure 2: efficient and inefficient units.

Table 4: Efficiency Units

Unit	Efficient	Unit	Efficient	Unit	Efficient	Unit	Efficient
DMU 1	0.577	DMU 9	4.097	DMU 17	0.388	DMU 25	0.673
DMU 2	0.37	DMU 10	0.665	DMU 18	0.817	DMU 26	1.794
DMU 3	0.54	DMU 11	0.547	DMU 19	0.367	DMU 27	0.057
DMU 4	1.664	DMU 12	1.536	DMU 20	0.305	DMU 28	0.398
DMU 5	0.832	DMU 13	0.802	DMU 21	0.668	DMU 29	0.715
DMU 6	0.791	DMU 14	0.922	DMU 22	1.057	DMU 30	0.307
DMU 7	0.499	DMU 15	0.894	DMU 23	0.481	DMU 31	1.181
DMU 8	0.662	DMU 16	0.714	DMU 24	0.815	DMU 32	1.121

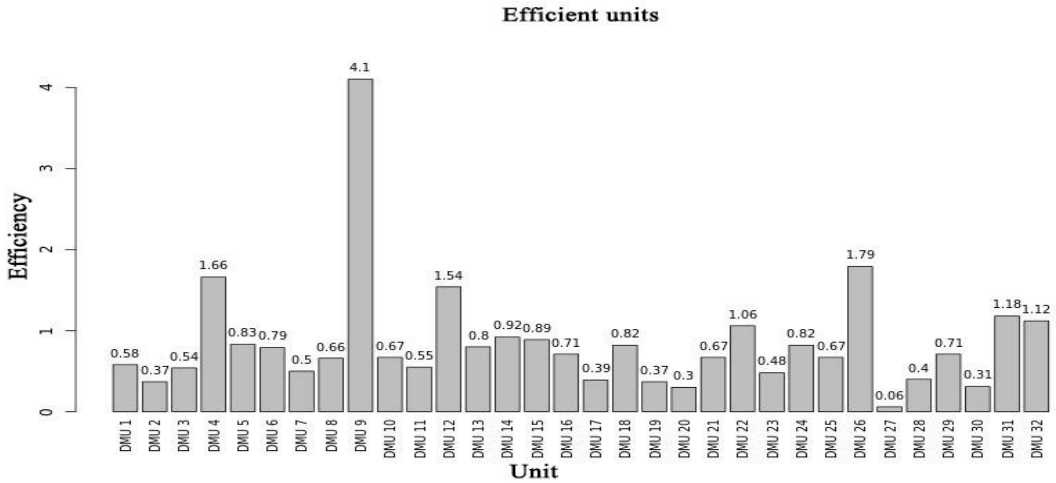

Figure 3: Efficiency Units based on Anderson-Peterson technique.

As shown in table 4, like the 1st method the units 31, 26, 22, 12, 9, 4 and 32 are super-efficient but in this method the units can be ranked based on the efficiency. Also, the minimum efficiency of DMU27 is 0.06 and then it is related to units of 20 and 30 as 0.30 and 0.31. So, the ranking of the super-efficient units based on efficiency units is shown in Table 5.

Table 5: ranking of the super-efficient units

Unit	Efficiency	Rank
DMU09	4.1	۰۱
DMU26	1.79	۰۲
DMU04	1.66	۰۳
DMU12	1.54	۰٤
DMU31	1.18	۰٥
DMU32	1.12	۰٦
DMU22	1.06	۰۷

$$\text{Max} \quad z = \sum_{r=1}^{s} y_{rj} \cdot u_r$$

$$\text{s.t:} \quad \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0$$

$$\sum_{i=1, i\neq j}^{n} v_i x_{ij} = 1$$

$$u_r, v_i \geq 0$$

$$f(x) = a_0 + \sum_{n=1}^{\infty} \left(a_n \cos \frac{n\pi x}{L} + b_n \sin \frac{n\pi x}{L} \right)$$

7. Conclusion

In this study, we have presented an empirical investigation to measure the relative performance of 32 chemical and pharmaceutical companies listed in Tehran Stock Exchange. The study has considered three inputs and three outputs for performance measurement and using constant return to scale data envelopment method, the study has determined the relative efficiency of all units and also performed supper efficiency among efficient units and provided appropriate ranking for these units. The review of methods and materials revealed that in the standard DEA seven DMUs are rated as efficient and tie for the top position in the ranking. On the other hand, as the results of this article show, the super efficiency score enables us to distinguish between the efficient observations. In addition, based on the results of our survey, we can conclude that most units where either efficient or close to their efficient utilization of their resources. Furthermore, the result showed that DEA technique by taking; the book value of total assets, Book value of equity, and General and administrative expenses as inputs and Company profit or loss, Return on Equity, and Return on assets as outputs the ability to integrate these ratios and turning them into a single criterion that is called efficiency. As supported by literature, a number of models have been proposed for measuring the relative performance of industries [4, 5, 37, 41, 43, 47, 49, and 50].

Acknowledgments

I acknowledge the invaluable support by the **Tehran Stock Exchange** where data for this study were collected. The clearance of the study by the Financial Data Processing Center is also gratefully acknowledged.

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HOW TO CITE THIS ARTICLE:
Vakil Alroaia, Y. (2021). Evaluating the Performance of Companies Listed in Tehran Stock Exchange based on Financial Ratios Using DEA), International Journal of Finance, Accounting and Economics Studies, 3(2): 1-14.
DOI:
Url: https://ijfaes.srbiau.ac.ir/article_21156.html
Journal homepage: https://ijfaes.srbiau.ac.ir