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DEA-Based Evaluation of the Oil Prices Effect on Industry: A Case Study of the Stock Exchange

Ali Taherinezhad[a,*], Alireza Alinezhad[a]
[a]*Department of Industrial Engineering, Qazvin Branch, Islamic Azad University, Qazvin, Iran*

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Abstract

This paper evaluates the impact of oil prices on the industry and the total index of the Tehran Stock Exchange. In addition, the impact of oil shocks on the Tehran Stock Exchange is also studied. The analyzed data are the weekly crude oil price data in the industry and the index of the Tehran Stock Exchange during the 10-year period from 2005 to 2015. For data analysis, this paper proposes an appropriate mathematical model based on the non-parametric technique of data envelopment analysis (DEA), which is a powerful mathematical tool for ranking decision-making units (DMUs). Ultimately, we used the proposed model to calculate the efficiency and ranking of 10 companies active in the food and beverage industry (except for the sugar group) and analyzed the results with the CCR model. Following that, the final ranking was done using the weighted average method. According to the results of the research, Mahram Production Group Company was ranked 1st in the weighted average method, and Shir Pegah West Azerbaijan was ranked second, and Nab Industrial Companies, Pars Livestock Feed, Georgian Biscuits, Iran Behnoosh, Pak Dairy, Behpak, Salemeen and Shir Pegah Isfahan ranked 3rd to 10th, respectively. The rest of the results have been discussed and analyzed in detail. The results of this research can have a beneficial and profound effect on the managerial insights of policymakers in the fields of stock exchange and the oil industry.

Keywords: Oil Price, Stock Exchange, Performance Evaluation, Data Envelopment Analysis (DEA).

1.Introduction

Financial markets are one of the most basic markets in any country. The conditions of these markets strongly affect the real sectors of the economy and are strongly influenced by other sectors. One of the important components of financial markets is the stock exchange. The stock exchange is an organized and official market for buying and selling companies under specific rules and regulations. One of the tasks of these markets is to help make the price of securities fair and speed up transactions (Schwartz et al., 2015). On the one hand, the stock exchange is a center for collecting savings and liquidity of the private sector in order to finance long-term investment projects. The stock market is affected not only by the national economy, but also by the global economy. The 1997 crisis of Southeast Asian countries had an impact on the world economy, including on the economy of Iran, through the reduction of the demand of these countries for crude oil and the fall in oil prices. It can be seen that there is a significant relationship between stock market developments, recession, and economic prosperity (Neacșu & Georgescu, 2024).

Oil is one of the world's strategic goods and is considered one of the production inputs of every country. As a result, the extreme fluctuations in oil prices are the main source of turmoil for the economies of oil-producing countries. On the other hand, since the oil revenues in Iran's economy are based on the principles of a single-product economy, it shows that the price of oil and its revenues are considered an exogenous factor and a driver of economic prosperity and recession in Iran. At the same time, the fluctuation outside the control of this factor causes most economic variables to fluctuate (Liu et al., 2023a).

The empirical literature on the impact of oil shocks and oil price fluctuations on the total index of the stock exchange can be divided based on developing and developed countries. In developing countries, economic growth is usually higher, and their demand for oil is increasing. On the other hand, energy consumption is more efficient in developed countries, and the production of goods and services in developing countries consumes more energy than developed countries. Hence, the changes in oil prices have a greater effect on the production situation of these countries and, as a result, the capital market returns and consequently the total index of their stock exchanges (Dhingra et al., 2024).

The importance of examining crude oil price fluctuations on Iran's economy as the second-largest producer of crude oil among the organization of crude oil producing countries in the world and due to the large volume of income from exports (more than 50% of the country's total exports) is very high to the extent that Iran has turned into a country dependent on crude oil revenues (more than 60% of the

* Corresponding Author. Email: atqiau@gmail.com

government's annual budget comes from crude oil exports) (Golkarami & Kord, 2024). So, the volatility in the world price of crude oil can have a great effect on Iran's economic structure. Although oil shocks can have a negative effect on the stock market due to the uncertainty they create in the financial markets, this issue depends on the nature of the shock (demand side or supply side). If the shock is from the demand side, the markets can have a positive response to this shock, and if the shock is from the supply side, the market response can be negative (Filis et al., 2011).

The necessity of checking and predicting oil price fluctuations using data envelopment analysis (DEA) comes from the fact that oil is a very important resource in the world economy, especially in Iran. Changes in oil prices and not paying attention to them can have significant effects on the economy of an oil-rich country. Therefore, in DEA, predicting oil price fluctuations is an important input in many decision-making processes (Ouenniche et al., 2014). DEA is a powerful method for calculating the efficiency of decision-making units (DMUs) such as companies, hospitals, universities, etc. In this method, the efficiency of DMUs is calculated using mathematical programming models. The most key feature of this method is that the DMUs under investigation are homogeneous and use inputs of the same type to produce outputs of the same type. This is the feature that makes the units comparable to each other (Taherinezhad & Alinezhad, 2022; Taherinezhad & Alinezhad, 2023).

The aim of the current research is to investigate oil price fluctuations via DEA models using recorded and definitive data in the Iranian stock market. This research shows its innovation and key contribution in the use of DEA models and Tehran stock exchange data in comparison with previous literature on the subject. The relevant organizations and bodies, having the innovative and practical results of this research, can take a smoother path to make correct decisions in this field at a wide and international level.

The rest of the paper is organized as follows: Section 2 reviews the most relevant recently published articles in this field. The research methodology and details of the collected data are presented and explained in Section 3. Section 4 includes computational results and discussion. Finally, in Section 5, conclusions, future research directions and suggestions are given.

2. Relevant Studies

In recent years, research in the field of decision science has accelerated and expanded greatly (Sarrafha et al., 2014; Alinezhad & Khalili, 2019a; Alinezhad & Khalili, 2019b; Alinezhad & Taherinezhad, 2020; Alinezhad et al., 2023). DEA is one of the important tools of decision science that has been widely used in various fields such as banking industry, medical industry, poultry industry, media industry, and other widely used industries (Alinezhad et al., 2007; Kiani Mavi et al., 2010; Alinezhad & Taherinezhad, 2021; Taherinezhad et al., 2023a; Taherinezhad et al., 2023b). In current study, if we look at DEA from a technical point of view, the oil industry and stock exchange market will be placed next to it as an application. Based on this, a comprehensive approach that simultaneously includes DEA, oil industry, and stock exchange market was used to review the literature. We limited the search for relevant articles to the last 15 years to examine novel innovations and contributions. In the following, the found studies are described in detail.

Ling et al. (2010) investigated the stock market in Malaysia with the DEA approach and measured the efficiency of companies in the Malaysian stock market. Finally, after the results were released, for each inefficient company, there was a set of optimal companies to be their reference company. Filis et al. (2011) investigated the relationship between crude oil prices and stocks in developed countries using the vector autoregressive (VAR) model. They conducted studies on the relationship between crude oil prices and stock indices in six member countries of the Persian Gulf Cooperation Council, whose study period was from 1999 to 2009. They used weekly data and showed that there is a negative relationship between the crude oil price and the stock index. Shahbazi et al. (2013) investigated the impact of crude oil price shocks on the stock market. They showed that the crude oil supply shock has no significant effect on the crude oil price. Only the shocks of crude oil demand and total demand are considered effective factors in stock returns on the Tehran stock exchange.

In recent years, the number of quantitative models available for predicting crude oil price fluctuations has grown widely. This makes evaluating the relative performance of models to find the most suitable model with low error a vital work. Xu and Ouenniche (2012) reviewed the relevant literature and found that most studies tend to compare models using a single criterion at a time. The gap that emerges here is: which forecasting model performs best when considering all criteria? Focusing on this research gap, Ouenniche et al. (2014) developed a slacks-based super-efficiency DEA model to evaluate the relative performance of competing crude oil prices' volatility forecasting models. Silvapulle et al. (2017) use an innovative nonparametric panel data approach to model the long-run relationship between the monthly oil price index and the stock market indices of ten major oil importing countries (i.e., the United States, Japan, China, South Korea, India, Germany, France, Singapore, Italy and Spain) introduced. Generally, the results showed that the non-parametric panel data model better captures the way in which the underlying oil-stock price relationship has evolved over time compared to the point estimates of the parametric counterpart.

Delgado et al. (2018) analyzed the variables of oil price, exchange rate and stock market index to explain how they interact with each other in the Mexican economy. The period examined in this study included monthly data from

January 1992 to June 2017. They implemented a VAR model that included the oil price, nominal exchange rate, Mexican stock market index, and consumer price index. Their results showed that the price of oil is statistically significant against the exchange rate. Finally, they came to the conclusion that the increase in the price of oil causes the increase in the exchange rate. Bagirov and Mateus (2019) designed a three-step study with the aim of expanding the understanding of the relationship between oil prices, stock markets, and financial performance of oil and gas companies. First, they studied the impact of oil price fluctuations on stock markets in Europe. In the second step, they examined the volatility spillover between oil and European stock markets. Finally, in the third step, the impact of crude oil price changes on the financial performance of oil and gas companies, both listed and non-listed, in the Western Europe region was investigated. Their findings confirmed the existence of a relationship between oil and European stock markets and proved that crude oil prices significantly and positively affect the performance of listed oil and gas companies in Western Europe.

In another study, Hashmi et al. (2022a) investigated the impact of crude oil prices on the Chinese stock market and selected industries using the VAR-DCC-GARCH (short for vector autoregressive, dynamic conditional correlation, and generalized autoregressive conditional heteroskedasticity) model in the period from December 26, 2001 to April 30, 2019. Their experimental results also showed that the effect of Brent crude oil price on the composite index of Shanghai and selected industries is significant. Following this research, Hashmi et al. (2022b) in another study investigated the interactions between oil prices, exchange rates and stock returns in Pakistan using quarterly data from January 2000 to December 2019. They demonstrated the use of quantile autoregressive distributed lag (ARDL) model in this research. Empirical findings showed that the effect of oil price and exchange rate on stock prices is different in bullish, bearish and normal conditions of the stock market.

Liu et al. (2023b) studied the heterogeneous effects of oil prices on the Chinese stock market based on a new decomposition method. They used the GAO (short for generalized additive outlier) method to control potential factors. In line with the trend of previous studies, Behera and Rath (2024) investigated the relationship between crude oil prices and stock returns in G20 countries. Using the dynamic connectedness approach and dataset from March 24, 2014 to December 15, 2023, they found volatility transmission between stock returns and crude oil prices. Their research findings provided important implications for investors and policymakers related to this field.

As we found out from reviewing the articles, the issue of the impact of oil prices on stock indices is one of the trending research issues in the world today, which is of particular importance. According to the reviewed articles, no research has been done that is completely similar to the present research. In the present study, we use the DEA technique to investigate the effect of oil prices on the Tehran stock exchange. For analysis, we consider a set of food industry companies as DMUs. From another point of view, the innovation and novelty of the current research are defined by the use of DEA in the specific case study. So that the data used in this study has not been tested in another study with the same approach.

3. Methodologies

In this paper, after reviewing the existing literature, hypotheses were proposed, and after determining the sample size and appropriate sampling method, data was collected, and then analysis was done using statistical techniques, and finally, the hypotheses were tested. In a general summary, it can be said that this research is a descriptive-survey type of research. In addition, since the results of this research can be used practically, this research contains an applied case study. In the field of applied studies (with a case study), analogical and inductive methods can be used to advance research. The method used in this article is also the deductive-inductive method. In this way, the theoretical framework and the background of the research have been collected through the library, articles and the Internet in a comparative manner. After that, information is collected to reject or confirm the hypotheses in an inductive format. Based on this, we used field studies to collect data and information with the aim of predicting cash and price returns using the DEA method. Based on the purpose of the research and by examining the theoretical framework of the subject, the hypothesis of the research is explained as follows: "It is possible to obtain the relationship between the changes in the price of crude oil and the total price index of the Tehran stock exchange using DEA". Plus, the details of the thematic, spatial and temporal domains of the current study are as follows: This research is thematically in the field of financial management science and the analysis of forecasting cash return and stock price return using DEA in companies admitted to the Tehran stock exchange. Spatial domain includes companies in the food and beverage industry (except the sugar group) in the Tehran stock exchange. Additionally, the time period chosen to collect data and test the hypotheses is 10 years between 2005-2015.

3.1. Sampling and Data Collection

As mentioned earlier, the statistical population of this research is all the companies accepted on the Tehran stock exchange, which are active in the industry of all kinds of food and beverage products (except the sugar group). Generally, there are common methods for sampling in humanities research, including simple random sampling, systematic random sampling, stratified sampling, cluster sampling, and multi-stage sampling (Berndt, 2020). The sampling method in this research is simple random sampling, so that all members of the statistical community have an equal chance of selection. In fact, in this research, the elimination random sampling method has been used. For sampling, first, the parent investment companies (holdings) in the industries mentioned above have been removed from the statistical population, and then the remaining companies have been selected as members of the sample if they meet the following conditions. Therefore, among all the companies active in the four investigated industries, the companies that met the following criteria for a period of 10 years (2005-2015) were selected as a statistical sample:

- The companies must be admitted to the Tehran Stock Exchange by the end of 2004.
- The financial history of companies must end at the end of March every year.
- Companies should not have changed their financial year during the periods in question.
- Companies should not stop their activities during the intended periods.
- The information they need should be available in the variable definition section.
- The accounting procedures used for the financial period should be the same.

There are a total of 22 companies active in the food and beverage industry (except sugar) on the Tehran stock exchange. The number of examined samples from this industry is 10 companies, so 45% of the companies in this industry have been investigated, and their names are as follows: 1) Behpak; 2) Iran Behnoosh; 3) Georgian Biscuits; 4) Pars Livestock Feed; 5) Salemeen; 6) Shir Pegah Isfahan; 7) Shir Pegah West Azerbaijan; 8) Nab Industrial Companies; 9) Mahram Production Group Company; 10) Pak Dairy.

The initial collection of data was done through library studies, and then it was finalized by receiving the financial information of the last few years from the companies admitted to the Tehran Stock Exchange. The financial data is extracted from the audited financial statements included in the Research, Development and Islamic Studies Management site of the Stock Exchange Organization (www.rdis.ir) and the stock reporting software, Tadbirpardaz and Rahevard Novin. At the same time, authentic domestic and foreign books and articles on the subject, the database of companies, and the stock exchange have also been used.

3.2. Variable Selection

3.2.1. Price Index & Cash Yield

Before defining the variables, consider the following notations:

- P_{it}: The price of the i^{th} company at time t.
- q_{it}: The number of stocks issued by the i^{th} company at time t.
- RD_t: The basis of the price index and cash yield at time t, which was equal to $\sum P_{i0}.q_{i0}$ at the time of origin (before adjustment).
- RD_{t+1}: The basis of the price index and cash yield at time $t+1$ (after adjustment).
- DPS_{it+1}: Cash dividend paid by the i^{th} company at time $t+1$.
- D_{t+1}: Total price index base at time $t+1$ (after adjustment).
- D_t: Total price index base at time t (before adjustment).

The dependent variable or output of DEA in this paper is the price index and cash yield with the same total income index with the symbol TEDPIX (short for Tehran Exchange Dividend Price Index), which has been calculated and published in Tehran stock exchange since April 1998. The changes in this index indicate the total return of the stock market, and it is affected by price changes and the cash return paid. This index includes all the companies admitted to the stock exchange, and its weighting and calculation methods are the same as the total price index of TEPIX (short for Tehran Price Index), and the only difference between the two is in their adjustment method. The price index and cash yield of the Tehran stock exchange are calculated based on Equation 1:

$$TEDPIX_t = \frac{\sum_{i=1}^{m} p_{it}q_{it}}{RD_t} \times 100 \qquad (1)$$

The basic adjustment of the TEDPIX index is done by Equation 2, which is written in the following form:

$$RD_{t+1} = \frac{\sum_{i=1}^{n} p_{it}q_{it} - \sum_{i=1}^{n} DPS_{it+1}}{\sum_{i=1}^{n} p_{it}q_{it}} \times RD_t + \frac{RD_t}{D_t} \times (D_{t+1} - D_t) \qquad (2)$$

As it is known, the base adjustment formula of the TEDPIX index consists of two parts. The first part is related to the cash yield paid by the companies, which causes the base adjustment of the said index. The second part is related to the adjustment items that are common between TEPIX and TEDPIX and includes items such as capital increases from the company's cash contribution. Consider a situation where companies have paid cash dividends and no event has occurred that would lead to a base adjustment of the TEPIX index. In this situation, D_t will be equal to D_{t+1} and the above formula will be calculated as Equation 3, which is written like this:

$$RD_{t+1} = \frac{\sum_{i=1}^{n} p_{it}q_{it} - \sum_{i=1}^{n} DPS_{it+1}}{\sum_{i=1}^{n} p_{it}q_{it}} \times RD_t \qquad (3)$$

As it is known with some precision, in this situation, RD_{t+1} will be smaller than RD_t and this will lead to an increase in the TEDPIX index. Now consider the situation where the cash dividend has not been paid by a company, but companies have increased their capital by bringing in cash. In this situation, based on Equation 4, we will have:

$$RD_{t+1} = RD_t + \frac{RD_t}{D_t} \times (D_{t+1} - D_t) \quad (4)$$

The calculation method of Equation 4 is such that the percentage changes of RD will be the same as D. For example, if D_{t+1} is 0.5 times D_t, RD_{t+1} will also be 0.5 times RD_t, and as explained, this is done in a situation where the cash interest paid is zero. In other words, if the cash dividend is not paid by the companies and only the capital increase is done by adding other companies to the stock exchange list or other cases, the percentage of base changes of TEPIX and TEDPIX will be equal.

3.2.2. Independent variables (DEA inputs)

In the previous subsection, the only DEA output variable i.e., TEDPIX was discussed in detail. In addition, this research considers 9 input or independent variables to sync with DEA models, which are as follows:

- x_1: The price of oil, which is the price per barrel of Iranian crude oil in the world markets.
- x_2: Inflation rate, which is the percentage change in the price index during a period. In this research, inflation means the price index of consumer goods and services.
- x_3: Exchange rate, which is the value of a country's currency in terms of another country's currency. Here, the exchange rate means the value of one dollar in the market.
- x_4: Housing price index, which is the percentage change in the housing price in the desired year compared to the base year.
- x_5: The volume of liquidity, which is the total amount of banknotes and securities in the hands of the people, plus demand deposits, long-term deposits and savings.
- x_6: Gross domestic product (GDP) at constant price, which is the Rial value of all final goods and services within the geographical area during one year at the price of the base year.
- x_7: The price of gold, which is the global price of each ounce of gold.
- x_8: The amount of housing production, which is the amount of housing that is built by different people in a year.
- x_9: Import, which consists of all goods that enter the country from all sources of entry.

3.3. DEA-Based Mathematical Model

The DEA method is based on a series of optimizations using linear programming, which is also called a non-parametric method. In this method, the efficient frontier curve is created from a series of points determined by linear programming. To determine the points, two assumptions of constant and variable efficiency can be used in relation to the scale. The linear programming method, after a series of optimizations, determines whether the desired decision-making unit is on the efficiency line or outside it. In this way, efficient and ineffective units are separated from each other. It should be mentioned: In this method, the objective function (output) can be maximized with respect to certain inputs, or it can be minimized by using its dual, that is, with respect to a certain input (Charnes et al., 1978). In addition to measuring the efficiency in this method, by using indices such as Malmquist, it is possible to calculate the productivity for each DMU and divide the efficiency changes into two parts: Changes due to efficiency and technology. Plus, it should be mentioned that DEA has calculated the productivity and efficiency measurement for DMUs with several outputs (Zhao & Morita, 2024).

The first DEA model is called CCR (short for Charnes, Cooper, Rhodes). The basis for the formation of this model is the definition of efficiency as the ratio of one output to one input. In other words, in the CCR model, to calculate technical efficiency, instead of using the ratio of one output to one input, the ratio of the weighted sum of outputs (virtual output) to the weighted sum of inputs (virtual input) is used. Charnes et al. (1978) proposed Equations 5 and 6 to determine the highest efficiency ratio and involve the inputs and outputs of other DMUs in the optimal weights of the unit under review, which represent the input-oriented deficit CCR model and the output-oriented deficit CCR model, respectively:

$$\begin{aligned}
&Max: \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}} \\
&s.t. \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1, j = 1,2,\dots,n \\
&u_r \ge 0 \ , \ v_i \ge 0 \\
&r = 1,2,\dots,s \ ; \ i = 1,2,\dots,m \qquad (5)
\end{aligned}$$

$$\begin{aligned}
&Min: \frac{\sum_{i=1}^{m} v_{ri} x_{io}}{\sum_{r=1}^{s} u_r y_{ro}} \\
&s.t. \frac{\sum_{i=1}^{m} v_{ri} x_{ij}}{\sum_{r=1}^{s} u_r y_{rj}} \ge 1, j = 1,2,\dots,n \\
&u_r \ge 0 \ , \ v_i \ge 0 \\
&r = 1,2,\dots,s \ ; \ i = 1,2,\dots,m \qquad (6)
\end{aligned}$$

The above fractional planning model is known as the CCR ratio model, where u_r is the weight of the r^{th} output, v_i is the i^{th} input, and o is the index of the decision maker unit under investigation ($o \in \{1,2,\dots,n\}$). y_{ro} and x_{io} are, respectively, the r^{th} output and i^{th} input values for the unit under consideration (unit o). Also, y_{rj} and x_{ij} are, respectively, the r^{th} output value and the i^{th} input value for the j^{th} unit. s, represents the number of outputs; m, represents the number of entries; And n also represents the number of units.

To convert the CCR ratio model into a linear programming model, we used Charnes and Cooper's method. In this method, the argument is that in order to maximize the value of a fractional expression, the denominator of the fraction should be considered equal to a fixed number, and the form of the fraction should be maximized. Based on this, the denominator of the fraction is set equal to 1, and new models are obtained as follows:

$$
\begin{aligned}
& Max \sum_{r=1}^{s} u_r\, y_{ro} \\
& s.t. \sum_{i=1}^{m} v_i x_{io} = 1 \\
& \sum_{r=1}^{s} u_r\, y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0\,, \quad j = 1, \dots, n \\
& u_r\,, v_i \ge 0\,, \\
& \quad i = 1,2, \dots, m \;\;, \quad r = 1,2, \dots, s \qquad (7)
\end{aligned}
$$

$$
\begin{aligned}
& Min \sum_{i=1}^{m} v_i x_{io} \\
& s.t. \sum_{r=1}^{s} u_r\, y_{ro} = 1 \\
& \sum_{i=1}^{m} v_i\, x_{ij} - \sum_{r=1}^{s} u_r y_{ij} \ge 0\,, \quad j = 1, \dots, n \\
& u_r\,, v_i \ge 0\,, \\
& i = 1,2, \dots, m \;\;, \quad r = 1,2, \dots, s \qquad (8)
\end{aligned}
$$

These models are called multiple forms. Equations 7 and 8 show the initial (multiplier) model of the input-oriented CCR and the initial (multiplier) model of the output-oriented CCR, respectively. The data collected in this research has been synced to CCR model, and the calculation results have been obtained. Figure 1 reflects the basic steps taken in this paper to implement DEA. It is necessary to explain that GAMS and MATLAB software are used in all steps.

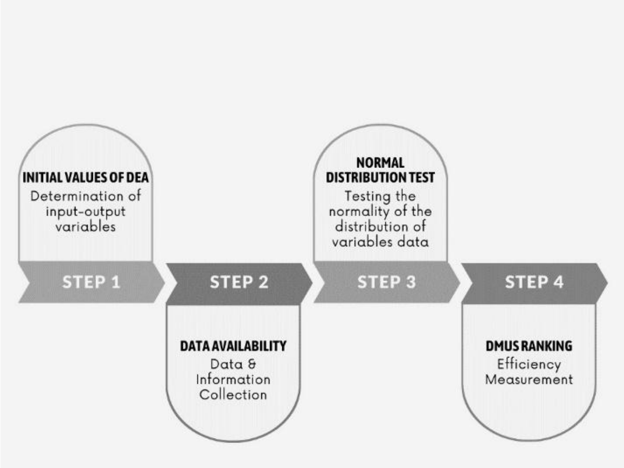

Fig. 1. Architecture and outline of the implementation steps of DEA technique in current research

4. Results and Discussion

4.1. Descriptive Statistics of Collected Data

In order to better understand the statistical population of the research and get more familiar with the research variables, before analyzing the statistical data, it is necessary to describe these data. Therefore, before testing the research hypotheses, the descriptive statistics of the variables used in the research were examined.

The average (or mean), as one of the central parameters, represents the center of gravity of the society, and in other words, it shows that if the average is placed instead of all the observations of the society, there will be no change in the sum total of the society's data. Also, the maximum shows the highest variable number in the statistical population, and the minimum shows the lowest variable number in the statistical population. Plus, the standard deviation (SD) is a measure of the amount of variation of a random variable expected about its mean. A low standard deviation indicates that the values tend to be close to the mean (also called the expected value) of the set, while a high standard deviation indicates that the values are spread out over a wider range. The results of descriptive statistics are presented in Table 1.

4.2. Data Normality Test

One of the tests that tests the normality of the used variables is the Jarque–Bera test (Jarque & Bera, 1980). Therefore, in this test, the following hypotheses are considered: H0) The data has a normal distribution; and H1) The data does not have a normal distribution.

Table 1
Descriptive statistics of the collected dataset

Variable	Mean	Median	Maximum	Minimum	Standard Deviation
TEDPIX	2.816	2.907	4.994	0.250	1.219
x_1	40.065	40.009	48.409	30.479	4.142
x_2	11.211	11.143	15.953	7.256	1.795
x_3	40.002	39.537	49.829	30.583	4.813
x_4	6.767	6.838	10.302	3.368	1.705
x_5	24.535	24.609	29.449	16.465	3.001
x_6	0.453	0.431	0.936	0.094	0.166
x_7	4.952	5.171	6.596	2.868	0.888
x_8	2.959	2.666	6.149	1.663	1.020
x_9	3.047	2.854	5.086	0.057	1.119

If the calculated values of the Jarque-Bera statistic (J-B) are not greater than the critical value of chi-square table, the normality of the distribution of residual sentences is not rejected. But when the sample size is large enough and other classical assumptions are also maintained, the deviation from the assumption of normality is usually insignificant, and its consequences are insignificant. According to Table 2, the p value of the test for all variables is greater than 0.05, it can be said that all variables follow the normal distribution at the 5% level (see Figure 2).

Table 2
The results of the Jarque-Bera test to determine the normality of the research data distribution

Variable	Sample Size	J-B	P-Value
TEDPIX	50	1.086	0.581
x_1	50	0.958	0.619
x_2	50	0.097	0.953
x_3	50	0.879	0.644
x_4	50	1.335	0.513
x_5	50	1.658	0.436
x_6	50	2.490	0.288
x_7	50	2.011	0.366
x_8	50	9.438	0.059
x_9	50	0.143	0.931

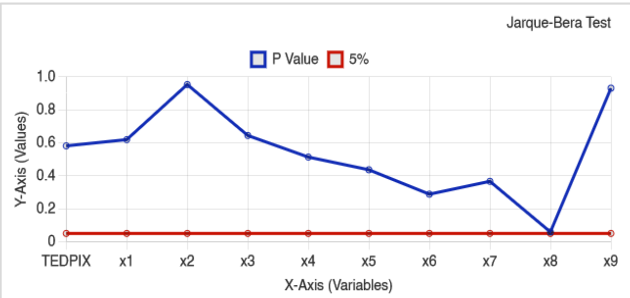

Fig. 2. Details of the Jarque-Bera test results (all p-values are greater than the 5% confidence level)

4.3. DEA Findings

In this research, each company has a DMU in each year, and the CCR model has been used to check the efficiency or inefficiency of DMUs. According to what was mentioned earlier, each company (or DMU) has 9 inputs and one output. The purpose of designing a dynamic productivity model in this research is to measure the performance of companies in the period 2005–2015 and also to compare different units. For this purpose, companies active in the industry of all kinds of food and beverage products (except the sugar group) have been selected for the model test. After implementing the CCR model through the data in GAMS software, the efficiency values of each company were obtained according to Table 3. The numbering of companies is in the same order as in subsection 3.1.

To rank the companies in the period 2005–2015, the number of efficient years can be counted for each company using the CCR model. Therefore, we ranked the companies with the most efficient years in the first place and ranked the rest in order. Accordingly, in the case of counting the efficient years, company number 7 gives itself the first rank. Companies' numbers 3, 5, 6, and 10 rank second; companies' numbers 2, 8, and 9 rank third; company number 1 ranks fourth, and company number 4 will rank fifth. The results of Table 3 show that if the number of efficient years for two companies is equal, the CCR model has a problem in ranking and assigns the same rank to both companies. For example, according to the results, 4 companies are ranked second. To solve this problem and differentiate between companies, the weighted average method has been used. In the following, we will describe the details of this method.

To achieve a common weight from the set of input and output weights, a logical relationship between the weights must be reached. In this method, unlike other methods, the efficiency of the units is the superiority of one weight over another. In the first step, we obtain the weights and efficiency of all decision units with the CCR model. In the second step, we examine the set of weights of inputs and outputs that we obtained in the first step with the CCR model and obtain the common set of available weights from Equation 9:

$$v_i^* = \frac{\sum_{j=1}^{n} v_{ij} e_j}{\sum_{j=1}^{n} e_j} \quad , i = 1,2, \dots , m \tag{9}$$

Table 3
Measured efficiency values for companies via CCR model

	Company									
DMU	1	2	3	4	5	6	7	8	9	10
2006	0.19761	0.85159	0.05606	0.08319	1	0.73983	1	0.2283	1	1
2007	0.72768	1	1	0.40092	1	0.60216	1	1	1	0.84501
2008	0.83236	1	1	0.71614	1	1	1	1	1	1
2009	1	1	0.62553	0.46413	1	1	1	0.35805	0.05593	0.51758
2010	1	0.33558	1	0.79099	1	1	0.01035	0.23993	0.54018	0.3605
2011	0.49625	1	1	1	0.62237	0.4599	1	1	1	1
2012	1	0.97895	1	1	0.40007	1	1	1	0.03809	1
2013	1	0.16244	0.87511	0.58687	1	1	1	1	0.19727	1
2014	1	1	1	1	0.86638	1	0.77722	1	1	1
2015	0.59001	1	1	0.73439	1	1	1	0.68093	1	1
Number of effective years	5	6	7	3	7	7	8	6	6	7
Rank	4	3	2	5	2	2	1	3	3	2

Table 4
Ranking of companies based on the weighted average method (e_j^* values)

	Company									
DMU	1	2	3	4	5	6	7	8	9	10
2006	0.100	0.408	0.031	0.080	0.570	0.106	1.985	0.146	2.986	0.308
2007	0.167	0.584	0.788	0.209	0.615	0.118	3.802	0.480	4.086	0.319
2008	0.105	0.461	0.337	0.097	0.527	0.185	2.103	0.354	1.272	0.475
2009	0.898	0.661	0.254	0.250	0.311	0.837	1.423	0.156	0.112	0.378
2010	0.517	0.099	0.690	0.254	0.755	0.165	0.021	0.067	0.359	0.110
2011	0.157	0.690	1.124	0.738	0.191	0.095	2.957	0.991	5.688	0.088
2012	0.528	0.121	0.269	1.657	0.047	0.405	1.280	1.010	0.032	0.391
2013	0.268	0.039	0.258	0.169	0.202	0.381	1.308	0.718	0.315	0.667
2014	1.438	0.996	0.835	1.592	0.128	0.632	0.853	1.451	4.374	1.483
2015	0.097	0.780	0.417	0.127	0.519	0.212	1.307	0.073	1.552	0.443

Where v_i^* $(i = 1,2,\dots,m)$ are the input characteristic weights and v_{ij} is the i^{th} input weight belonging to the j^{th} unit and e_j $(j = 1,2,\dots,n)$ is the efficiency of the j^{th} unit obtained from the CCR model. In this method, the characteristic weight is an average of the input weights, and the contribution of each weight in this ratio is the efficiency. As a result, any weight that corresponds to more efficiency will have a greater effect on the characteristic weight. Similarly, we obtain the set of joint weights of the outputs from Equation 10:

$$u_r^* = \frac{\sum_{j=1}^{n} u_{rj} e_j}{\sum_{j=1}^{n} e_j} \quad ,r = 1,2,\dots,s \qquad (10)$$

Where u_r^* $(r = 1,2,\dots,s)$ is the characteristic weight of the r^{th} output, u_{rj} is the weight of the r^{th} output of the j^{th} unit, which is obtained from the CCR model and e_j $(j = 1,2,\dots,n)$ is the efficiency of the j^{th} unit obtained from the CCR model.

The advantages of this method are that we obtain the common set of weights without solving a new model and using the results of the CCR model. The common set of weights in this method considers the proper proportion of weight and efficiency factors. In this method, a weight is neither omitted nor rounded, but a common weight with the closest feature to all units is considered. After obtaining the common set of weights, we need to calculate the efficiency of the decision units by Equation 11:

$$e_j^* = \frac{\sum_{r=1}^{s} u_r^* \; y_{rj}}{\sum_{i=1}^{m} v_i^* \; x_{ij}} \quad ,j = 1,2,\dots,n \qquad (11)$$

Table 4 shows the calculation results of e_j^* for each company between the time period of 2005-2015. After calculating e_j^* for DMUs, the ranking of units is changed and only one unit is selected as the best efficient unit. This changes in ranking can be seen in Table 4. Table 5 also reflects the ranking comparison of the CCR method and the weighted average method. According to table 5, the CCR method assigns the first rank to company number 7 and the weighted average method assigns the first rank to company number 9.

Table 5
The final ranking of companies based on the CCR and the weighted average methods

Rank	CCR Method	Weighted Average Method
1	Company No. 7	Company No. 9
2	Company No. 3, 5, 6, and 10	Company No. 7
3	Company No. 2, 8, and 9	Company No. 8
4	Company No. 1	Company No. 4
5	Company No. 4	Company No. 3
6	-	Company No. 2
7	-	Company No. 10
8	-	Company No. 1
9	-	Company No. 5
10	-	Company No. 6

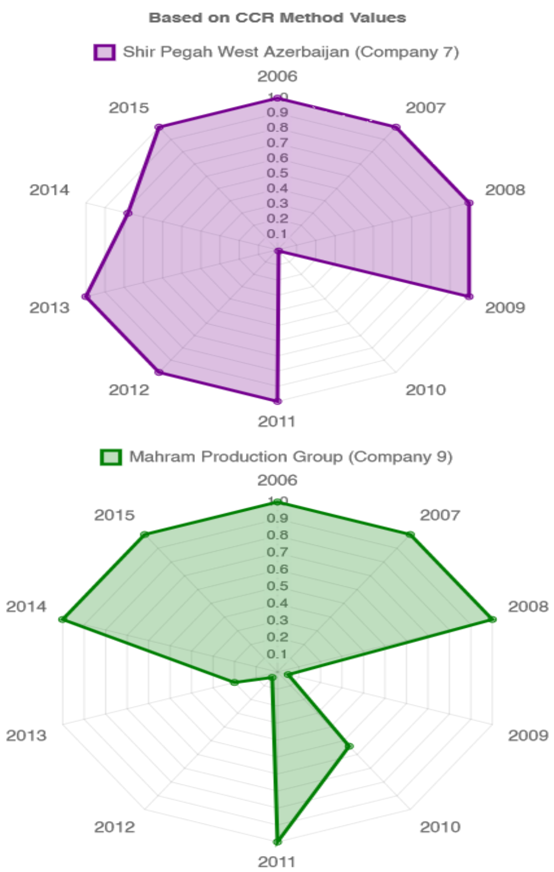

Fig. 3. Radar chart for efficiency values of Mahram Production Group and Shir Pegah West Azerbaijan

5. Conclusion

In this research, we evaluated and investigated the effect of oil price in the industry using DEA technique in the companies admitted to the Tehran stock exchange. By using CCR and weighted average models and considering the time factor as DMU, dissimilar units can be compared with each other in a special way. The mentioned comparison, practically, has provided the basis for evaluating the performance of different companies with each other. According to the results of the research, Mahram Production Group Company ranked 1st in the weighted average method, and Shir Pegah West Azerbaijan Company ranked 1st in the CCR method. The reason for this difference in the CCR method and the weighted average method is that company number 9 had an efficiency close to 1 in all years between 2005 and 2015, or, in other words, it was on the frontier of efficiency. On the other hand, Shir Pegah West Azerbaijan Company has been efficient in eight years of the investigated period, but in the remaining two years, it was very far from the efficiency limit. This difference is so great that in the weighted average method, this distance is completely felt, and it has caused Shir Pegah West Azerbaijan Company to be ranked second in the final ranking (see Figure 3). According to this inference, we rank all companies based on the weighted average method, so the ranks number 3 to 10 are given to Nab Industrial Companies, Pars Feed, Georgian Biscuits, Behnoosh Iran, Pak Dairy, Behpak, Salemeen, and the milk of Pegah Isfahan is reserved, respectively.

Based on the results obtained and considering the effect of the oil price on the industry of the companies listed on the Tehran stock exchange in this research, it is suggested to the users of the financial statements of the companies listed on the stock exchange that they should consider this in their investment decisions. Pay attention to the subject. Also, it is suggested to the managers of the companies admitted to the Tehran stock exchange to pay attention to this issue in order to make the capital market as efficient as possible and to provide practical measures and the necessary platform for this.

It seems that the following ideas can complement the current research:

- Performance evaluation of safety processes in gas refineries using DEA.
- Measuring the productivity of companies admitted to the Tehran stock exchange using DEA.
- Evaluating the performance of listed companies in the Tehran stock exchange under uncertainty using fuzzy method, robust optimization, etc., because using these techniques can produce more reliable results and a more accurate model of the real world.

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