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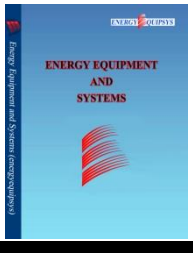


# A new approach for performance evaluation of energy-related enterprises

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## ABSTRACT

*Oil is among the most effective and the largest industries in the world. Given that it supplies a large percentage of the world's energy and plays a significant role in the national power and international credit of countries, it has a huge impact on our world today. Iran has huge oil reserves, and plays a key role in the exchange of the required energy in the world. In order to improve the performance of this critical industry, it is necessary to evaluate the performance of petroleum producing companies. The main purpose of this paper is to present the first three-stage data envelopment analysis-based approach, integrated with a balanced scorecard for performance evaluation of oil companies. Regarding the cause and effect relationships among different aspects of the balanced scorecard, its indicators are employed as input and output variables of the data envelopment analysis model and the efficiency is calculated. The results indicated that among the oil companies investigated in this paper, the National Iranian South Oil Company and Aravindan Oil & Gas Company recorded the highest and lowest efficiencies, respectively. The proposed approach by authors provides a valuable tool for managers in the oil industry to evaluate the performance and take action for performance improvement.*

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## 1. Introduction

Energy as the food and lifeblood of the national economy is indeed the driving force of most economic activities. It plays a special role in economic growth as well as vital diplomatic, security, and environmental problems. Also, economic development depends largely on the level of energy consumption such that the well-of countries rely more heavily on energy than poorer ones; industrial energy consumption differs between 30 to 70 percent of the total energy consumed in various countries [1]. Oil is still the main source of energy in the world. In 2004, as an energy superpower, Iran produced 5.1 percent (equal to 3.9 million barrels per day) of the world's crude oil needs. Also, oil proceeds comprised 40-50 percent of the government's budget in 2006[1]. Nevertheless, the significance

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1. http://www.eia.doe.gov/emeu/cabs/Iran/Background.html.

of the oil industry to Iran's economy has been greater and it has been the driving force of economic development, government's annual budget, and the main financial source for government projects. Therefore, with regard to the key and critical role of the oil industry, it seems necessary to evaluate and measure the performance of oil producing companies. Performance assessment is a significant problem for all systems including petroleum companies. It can identify their strength and weakness points, monitor their function quicker and broader, recognize ways to meet the customers' needs, understand their processes, improve their internal operations, and help them to attain certain objectives.

A few numbers of studies have focused on the efficiency and performance evaluation of oil companies. Wang et al. [2] proposed a DEA-based approach for environmental evaluation of different industrial sectors in the United States. They investigated 7 different sectors in which oil and gas companies were surveyed in the energy sector. The results of their study indicated that investors and customers pay serious attention to the green image of companies. Sueyoshi and Wang [3] utilized a DEA-based approach to assess the operational and environmental performance of firms in the United States. In another paper, non-radial models were employed to present three kinds of unification for DEA environmental evaluation: unified efficiency, unified efficiency under managerial disposability. This approach was implemented to compare the performance of national oil companies with that of international oil firms [4]. Mehdizadeh et al. [5] surveyed the performance of the thermal oil boiler, the beneficial approaches for its efficiency improvement and saving energy. This study demonstrated that the oil boiler utilized only 55 percent of its capacity and in this case, the oil boiler's efficiency was 77.48 percent based on the heat loss method. In their paper, Saad et al. [6] investigated the progress of the dynamic supply chain performance through the resource-based view and organizational learning theory in the oil and gas industry in Malaysia. Tahmasebi et al. [7] assessed the performance of a gas turbine power system and investigated the effect of various operating circumstances.

Traditional tools of performance evaluation focus mainly on financial aspects; therefore, managers are limited to focus only on short-term performance. This paper has attempted to present a novel approach for evaluating the long-term performance of organizations. To achieve this aim, this study integrated Balanced Scorecard (BSC) and three-stage Data Envelopment Analysis (DEA). The BSC methodology is a new performance measurement system introduced by Kaplan and Norton [8]. It can solve the problem mentioned above by considering tangible and intangible organization's objectives and assessing their performance from different aspects: financial and non-financial (learning and growth, internal process, customer, and financial). The lack of a mathematical logic for performance measurement is an important weakness of the BSC. The DEA is implemented to solve this problem. The DEA proposed by Charnes et al. [9] is a non-parametric method which is employed to evaluate the efficiency of the Decision Making Unit (DMU) in various fields such as the hotel industry, financial institution, education, and health care.

For performance evaluation, a relatively large number of studies have been carried out on the concurrent utilization of DEA and BSC. In this section, some of them are mentioned: Wang and Chien [10] provided an improvement plan for 32 Taiwanese LED companies from 2010 to 2014 by the simultaneous use of BSC and DEA. Eilat et al. [11] focused on the comparison of individual R& D projects using the concurrent application of BSC and DEA models. In a paper by Chiang and Lin [12], BSC and DEA models were simultaneously applied to measure and compare the efficiency of 39 auto companies and 30 national commercial banks in the US. To measure the performance of a public research institute, Seo et al. [13] constructed a performance management system by integration of the BSC-DEA models. Also, analytical hierarchy process (AHP) was employed to determine the weight of BSC indicators. Oliveira and Cicolin [14] analyzed the logistics performance of Brazil's corn export using the integrated BSC and DEA models. In another research carried out by Chen and Chen [15], a systematic approach based on the integrated BSC-DEA model was developed to assess the performance of 30 Taiwanese semiconductor companies. In their paper, Zervopoulis et al. [16] proposed a BSC-DEA methodology to evaluate the performance of 32 retail firms in the US.

Although the mentioned studies employed a classic DEA model to integrate with BSC, García- Valderama et al. [17] implemented 5 DEA models in order to investigate the causal

linkages among the perspectives of BSC in the context of R&D activities. In the first model, indicators of financial and customer perspectives were respectively utilized as output and input variables of the DEA model. The second model employed customer perspective's indicators as outputs and innovation perspective factors as inputs. The indicators of innovation and internal process were respectively employed as outputs and inputs of the third model. The output and input factors of the fourth model were respectively chosen from the internal process and learning aspects. The last model selected its output and input factors from financial and learning dimensions. They collected and investigated the data of 90 chemical and pharmaceutical companies to survey the relations among the 5 models mentioned above. Amado et al. [18] embedded the BSC structure in 4 DEA models in which the outputs of a model was selected as the inputs of the next one. In the first model, the inputs and outputs were selected from the aspect of learning and growth. These outputs were considered as inputs of the second model and the outputs were from the internal process perspective. The third model chose its inputs from internal process and its outputs from the customer aspect. The input and output variables of the fourth model were respectively chosen from the customer and financial perspectives. They provided this conceptual framework for assessing the performance of 14 regional delegations in the maintenance department of vertical transportation. In their study, Shafiee et al. [19] surveyed the relationships among the BSC's aspects in a food supply chain's system. They chose all input and output variables in one of the BSC's perspectives and embedded this structure in 4 DEA models.

Table 1 provides a summary of various studies which have integrated BSC and DEA models for different objectives.

From the literature review, it is clear that attention has not been paid to evaluation of the performance of oil companies from different aspects, financial and non-financial. On the other hand, as shown in Table 1, despite different studies on the integration of BSC and DEA models, none has employed a three-stage DEA model for performance evaluation. Therefore, the authors took responsibility of introducing the first three-stage DEA-based approach for evaluation of oil companies' performance.

The remaining part of this paper is organized as follows: at first, the concept of causal relationships of balanced scorecard is explained in Section 2. Section 3 is related to the details of the multi-stage DEA method. The proposed approach of this paper is presented in Section 4. A case study is provided in Section 5 and its results are discussed in Section 6. Finally, conclusion remarks are given in Section 7 to summarize the contribution of the paper, as well as the applications of the approach proposed in this study.

**Table 1.** Previous studies which combined the DEA and the BSC models.

| Study | Analysis methods | The purpose of integration of the BSC and DEA models |
|---|---|---|
| Amado et al. [18] | 4 DEA models, BSC | To assess the performance of 14 regional delegations in the maintenance department of vertical transportation |
| Chen and Chen [15] | DEA, BSC | To assess the performance of 30 Taiwanese semiconductor companies |
| Chiang and Lin [12] | DEA, BSC, Principal Component Analysis, Factor Analysis, Canonical Correlation Analysis | Applied to measure and compare the efficiency of 39 auto companies and 30 national commercial banks in the US |
| Eliat et al. [11] | DEA, BSC | To make comparison of individual R& D projects |
| García- Valderama et al. [17] | 5 DEA models, BSC, Pearson's Correlation Coefficient, Factor analysis | To investigate the causal linkages among BSC's perspectives in the context of R& D activities include 90 chemical and pharmaceutical companies |
| Oliveira and Cicolin [14] | DEA, BSC, route analysis | To analyze the logistics performance of Brazil's corn export |
| Seo et al. [13] | DEA, BSC, AHP | To measure the performance of public research institute |
| Shafiee et al. [19] | Four- stage DEA model, BSC, DEMATEL | To survey the relationships among BSC's aspects in a food supply chain's system |
| Wang and Chien [10] | DEA, BSC | To provide an improvement plan for 32 Taiwanese LED companies |
| Zervopoulis et al. [16] | DEA, BSC | To evaluate the performance of 32 retail firms in the US |

## 2. Balanced scorecard model

Kaplan and Norton introduced the balanced scorecard in 1992[8]. This innovative approach is able to measure the performance of organization from different aspects: both financial and non-financial. This tool enables managers to replace a causal linkage among different aspects of the BSC, through their strategic measures, instead of performance indices in four independent dimensions. These relationships are very significant and vital for performance assessment because the chain of causal relations reflects dynamic variations in strategies and present how an organization creates its values. In 2004, BSC's innovators proposed a strategy map to empower managers to perceive a hierarchical structure among BSC's perspectives whereby improvement in learning and growth aspect (level 1) result to a better internal process (level 2) which promotes the value propositions delivered to customers (level 3) and ultimately, in financial performance (level 4). This cause and effect relationship is presented in Fig. 1.

If intangible investment in learning and growth perspective such as employee education, research and development, knowledge sharing, and employee empowerment do not culminate in improved financial performance, it is essential to managers to depict a new one. Ittner and Lucker [20] studied causal linkages in telcommunications industries. In the hotel industry, Liang and Hou [21] identified the relations between the customer and financial aspects but could not prove the existence of these relationships between learning and financial perspectives. Lucianetti [22] reported that the adopters of BSC in Italy disregard these relationships; ultimately, they deduced that if managers ignore this, the BSC's property will not enjoy all the utilities of BSC employment. According to the given relationships among BSC's dimensions, the classic DEA method cannot be implemented as an appropriate mathematical tool and so, a suitable framework was implemented to arrange several interconnected DEA models in the present study.

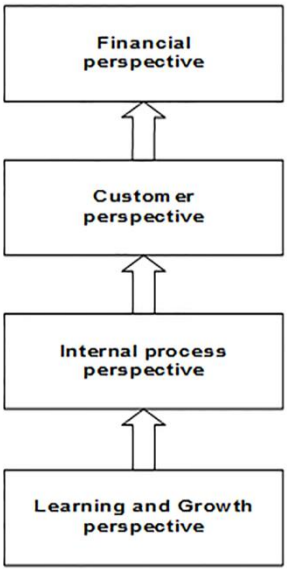


**Fig.1.** The causal relationships between perspectives of BSC.

## 3. Multi-stage data envelopment analysis

The classic DEA model considers a process as a black box, which utilizes a single model for the transformation of inputs into outputs. All decision makers should avoid the black box approach and measure the sub-DMU's efficiency to enjoy beneficial information for performance improvement. Färe and Grosskopf [23] introduced the network DEA model in 2000. They identified the inefficiency of resources by opening the mentioned black box.

Suppose there is a cascade system of $h$ processes. $X_{ij}$ and $Y_{rj}$ are considered as the inputs and outputs of the system, respectively. $Z_{pj}^{(t)}$ is defined as the *p-th* intermediate product, $p = 1, \ldots, q$, of process $t$, $t=1, \ldots, h-1$, for $DMU_j$. The intermediate products are outputs of process $t$ and inputs of process $t+1$. Also, the intermediate products of the last process $h$ are the outputs of the system. Just for simplification, it is supposed that the number of intermediate products is the same for all processes, although it can be different. This model is presented in Fig 2.

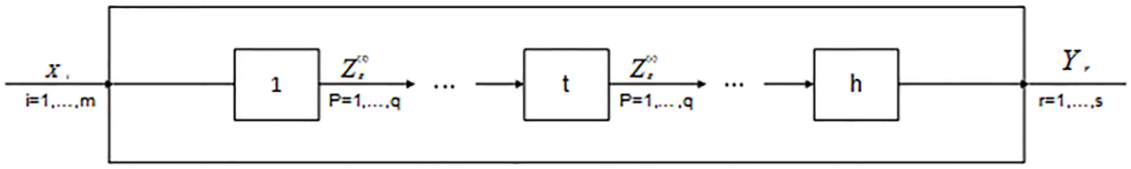


**Fig.2.** Cascade system.

The efficiency of DMUj is computed by the following equation ($u_r$, $v_i$, and $w_p$ are considered as multipliers).

$$E_k = \max \sum_{r=1}^{s} u_r Y_{rk}$$

*s.t.*

$$\sum_{i=1}^{m} v_i X_{ik} = 1$$

$$\sum_{r=1}^{s} u_r Y_{rj} - \sum_{i=1}^{m} v_i X_{ij} \le 0$$

j=1,...,n

$$\sum_{p=1}^{q} w_p^{(1)} Z_{pj}^{(1)} - \sum_{i=1}^{m} v_i X_{ij} \le 0$$

j=1,...,n

$$\sum_{p=1}^{q} w_p^{(t)} Z_{pj}^{(t)} - \sum_{p=1}^{q} w_p^{(t-1)} Z_{pj}^{(t-1)} \le 0$$

j=1,...,n , t=2,...,h-1

$$\sum_{r=1}^{s} u_r Y_{rj} - \sum_{p=1}^{q} w_p^{(h-1)} Z_{pj}^{(h-1)} \le 0$$

j=1,...,n

$$u_r, v_i, w_p^{(t)} \ge \varepsilon$$

r=1,...,s , i=1,...,m (1)

p=1,...,q , t=1,...,h-1

$W_p^{(t)}$ is associated with the $p$-th intermediate product of process $t$. If $u_r^*$, $v_i^*$ and $w_p^{(t)*}$ are considered as optimal multipliers, the efficiency of each process for $DMU_k$ is calculated as:

$$E_k^{(1)} = \sum_{p=1}^{q} w_p^{(1)*} Z_{pk}^{(1)} \Big/ \sum_{i=1}^{m} v_i^* X_{ik} \quad (2)$$

$$E_k^{(t)} = \sum_{p=1}^{q} w_p^{(t)*} Z_{pk}^{(t)} \Big/ \sum_{p=1}^{q} w_p^{(t-1)*} Z_{pk}^{(t-1)} \quad (3)$$

t=2,...,h-1

$$E_k^{(h)} = \sum_{r=1}^{s} u_r^* Y_{rk} \Big/ \sum_{p=1}^{q} w_p^{(h-1)*} Z_{pk}^{(h-1)} \quad (4)$$

$E_k^{(t)}$, $t = 1,\ldots, h$ is equal to $\sum_{r=1}^{s} u_r^* Y_{rk} \Big/ \sum_{i=1}^{m} v_i^* X_{ik}$ that is the efficiency of the system. A DMU is regarded as efficient, provided that all its processes are efficient.

## 4. Methodology

In the present study, the BSC and three-stage DEA techniques are implemented as an integrated methodology for evaluation of oil companies' performance. At first, it was assumed that some indicators for each dimension of BSC and with respect to the causal linkages in the BSC, these indicators are considered as inputs and outputs of the DEA model. In order to make the structure of the network DEA model, the outputs of each stage were considered as inputs of the next one and so, a three-stage DEA structure is formed. Finally, the efficiency of all stages was computed as well as the total efficiency through Eqs. (1), (2), (3), and (4) as presented in Section 3.

It must be mentioned that in none of the studies carried out so far in the field of integration of BSC and multi-stage DEA, such a structure is yet to be considered. In previous studies (for example [18], [19]) the BSC structure is often embedded in the DEA model and a four-stage DEA model is constructed in which the input and output factors of each stage are adopted from the corresponding BSC's perspective. However, in our proposed structure, the inputs of one stage, for example Stage 2, are selected from the internal process perspective while its outputs are from the next perspective, customer perspective.

## 5. Case study

In this section, a case study is presented to elucidate the details of our proposed approach. This case is related to six listed Iranian oil companies and is shortly explained in Table 2.

### 5.1. Measurement of bsc's perspectives

According to our case studies, in the BSC model, learning and growth perspective in which necessary indices for development of the future business are examined, contains four indicators: 1) employee education (L1), 2) research and development (L2), 3) employee knowledge sharing (L3), and 4) enhancing the labor force (L4). Internal process aspect which assess the activities should be developed to possess the ability to respond to emergencies (P1), improvement of efficiency (P2), and employee productivity (P3). The stakeholder's perspective consists of indicators which are related to internal and external customers' satisfaction, the core of

business profitability: air pollution (S1), impact on ecosystem (S2), customer relationship management (S3), job security for employees (S4), and quality of life (S5). The financial perspective's indicators present both costs and benefit and include revenue growth rate (F1), financial risk reduction (F2), and diminishing the overall cost (F3). It must be mentioned that Iran's economic structure is a governmental structure in which in addition to profitability, citizenry and public interests are important. Hence, this study considered stakeholder's perspective instead of customer's perspective. The indicators of this perspective comprise the interests of all stakeholders. It may even include environmental and social factors. The selected indicators for the BSC model have been characterized in Table 3 and their causal linkages are displayed in Fig. 3.

**Table 2.** List of companies studied in this research.

| Symbol | Firm | Explanation |
|---|---|---|
| DMU1 | National Iranian South Oil Company (NISOC) | One of the most famous companies of the NIOOC family located in Khuzestan province which is recognized as the principal oil resources of Iran. This company is liable for onshore oil fields in the south of Iran |
| DMU2 | Khazar Oil Exploitation and Production Company | This company is responsible for offshore and onshore in Iran's Caspian sector |
| DMU3 | Pars Oil and Gas Company (POGC) | The liability of this company is related to offshore North and South Pars gas fields |
| DMU4 | Aravindan Oil & Gas Company (AOGC) | This company is responsible for progress in the Arvand oil & gas fields. This company produces oil and gas from Yadavaran, Omid, Azadegan, Arvan and other fields in the west of Karun River |
| DMU5 | Iranian Offshore Oil Company (IOOC) | The main focus of this company is on the set up of ancillary facilities, and a production platform. It is in charge of offshore oil fields in the Persian Gulf and South Pars |
| DMU6 | National Iranian Central Oil Company | All activities in the central oil and gas fields of the country with the exception of the oil-rich southern Khuzestan province, offshore and Caspian is controlled by this entity |

**Table 3.** Measurement of the BSC model.

| Perspective | Indicators | Description |
|---|---|---|
| L: Learning and growth | (L1) Employee training programs | The training programs considered for staff on specific fields related to their job processes or relationships |
| | (L2) Amount of investment in the research and development | Systematic activities include basic and applied researches aimed at improving goods or services |
| | (L3) Knowledge sharing culture | Exchanging knowledge (information, skills, expertise, ...) among staff |
| | (L4) Enhancing the labor force skills | Increasing the ability and skills of employees |
| P: Internal process | (P1) Ability to respond to emergencies on time | Staff readiness to respond to emergency or unpredictable cases. |
| | (P2) Improvement of efficiency | Increasing efficiency |
| | (P3) Employee productivity | Evaluation of employee's efficiency may be in terms of the staff's outputs in a period of time |
| S:Stakeholder | (S1) Emission of air pollutant | Contamination of air through foreign substances |
| | (S2) Impact on ecosystem | Human impact on environment |
| | (S3) Customer relationship management | Strategies employed by organzation in order to improve and analyze customer relationships and detect customers' needs |
| | (S4) Job security for employees | Assurance (or lack of it) that a staff has about his/ her continuous employment |
| | (S5) Quality of life | The standard of health and comfort; necessary things for a good life |
| F: Financial | (F1) Revenue growth rate | The rate of increasing (or decreasing) organization's income in a specific time |
| | (F2) Financial risk reduction | Decreasing financial or operating risk |
| | (F3) Diminishing the overall cost | Decreasing fixed and variable costs |

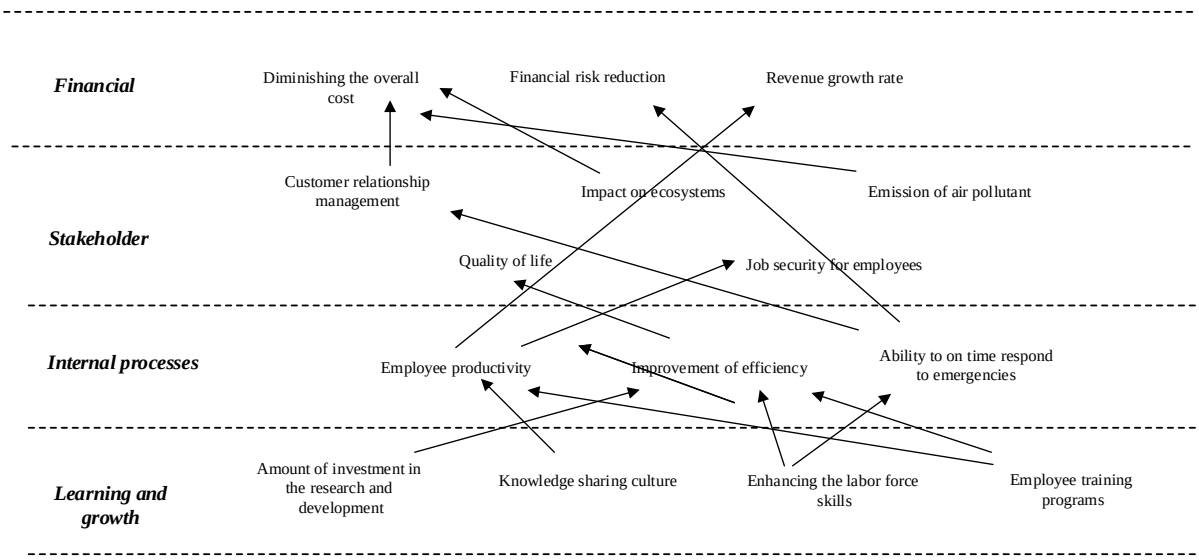


**Fig.3.** The cause and effect relationships among indicators.

## 5.2. Modeling the DEA structure

With regard to the cause and effect relationships among BSC's perspectives, the indicators introduced in previous sections were considered as inputs and outputs of the three-stage DEA structure, in this way the inputs of Stage 1 capture the indices of learning and the growth aspect is comprised of employee education (L1), research and development (L2), employee knowledge sharing (L3), and enhancing the labor force skills (L4); the outputs of this stage are ability to respond to emergencies (P1), improvement of efficiency (P2), and employee productivity (P3) which belong to the internal process. In order to make the structure of the network DEA model, the outputs of each stage were considered as the inputs of another one and so a three- stage DEA structure is formed. Therefore, the outputs of Stage 1 are considered as inputs of Stage 2 while the outputs of this stage were chosen from stakeholder perspective: air pollution (S1), impact on ecosystems (S2), customer relationship management (S3), job security for employees (S4), and quality of life (S5). Ultimately, Stage 3 consists of inputs which are the outputs of Stage 2 and its outputs are comprised of revenue growth rate (F1), financial risk reduction (F2), and diminishing the overall cost (F3) selected from the financial perspective. Figure 4 graphically displays the DEA structure according to our proposed structure. Also, Tables 4, 5, and 6 present numeral values of input/ output variables of stages 1, 2, and 3, respectively. These data were extracted from Rabbani et al. [24].

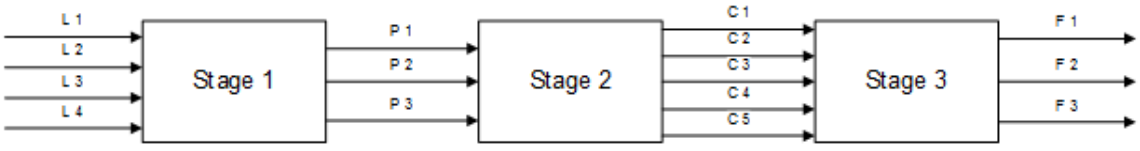


**Fig.4.** The proposed three-stage DEA model.

**Table 4.** The DEA input/output variables of Stage 1.

| DMU | Inputs | | | | Outputs | | |
|---|---|---|---|---|---|---|---|
| | L1 | L2 | L3 | L4 | P1 | P2 | P3 |
| 1 | 6.587 | 7.780 | 3.403 | 4.963 | 6.523 | 5.043 | 4.117 |
| 2 | 5.043 | 7.593 | 5.597 | 4.187 | 4.140 | 6.097 | 4.137 |
| 3 | 6.410 | 6.703 | 4.927 | 3.977 | 3.953 | 3.890 | 4.387 |
| 4 | 4.927 | 3.883 | 3.373 | 5.030 | 4.837 | 3.963 | 3.357 |
| 5 | 4.747 | 5.187 | 3.853 | 6.107 | 4.817 | 4.697 | 3.373 |
| 6 | 6.260 | 6.383 | 4.593 | 6.787 | 6.173 | 5.107 | 4.710 |

**Table 5.** The DEA input/output variables of Stage 2.

| DMU | Inputs | | | | Outputs | | | |
|---|---|---|---|---|---|---|---|---|
| | P1 | P2 | P3 | S1 | S2 | S3 | S4 | S5 |
| 1 | 6.523 | 5.043 | 4.117 | 5.053 | 4.103 | 6.810 | 4.253 | 6.070 |
| 2 | 4.140 | 6.097 | 4.137 | 3.520 | 5.040 | 6.640 | 3.993 | 4.847 |
| 3 | 3.953 | 3.890 | 4.387 | 4.857 | 2.880 | 4.917 | 2.363 | 5.380 |
| 4 | 4.837 | 3.963 | 3.357 | 3.707 | 4.770 | 5.077 | 4.593 | 4.020 |
| 5 | 4.817 | 4.697 | 3.373 | 4.957 | 6.373 | 5.820 | 4.897 | 3.520 |
| 6 | 6.173 | 5.107 | 4.710 | 3.290 | 5.030 | 7.620 | 5.043 | 6.457 |

**Table 6.** The DEA input/output variables of Stage 3.

| DMU | Inputs | | | | | Outputs | | |
|---|---|---|---|---|---|---|---|---|
| | S1 | S2 | S3 | S4 | S5 | F1 | F2 | F3 |
| 1 | 5.053 | 4.103 | 6.810 | 4.253 | 6.070 | 7.507 | 5.737 | 4.077 |
| 2 | 3.520 | 5.040 | 6.640 | 3.993 | 4.847 | 6.593 | 7.770 | 5.040 |
| 3 | 4.857 | 2.880 | 4.917 | 2.363 | 5.380 | 3.750 | 4.920 | 3.403 |
| 4 | 3.707 | 4.770 | 5.077 | 4.593 | 4.020 | 4.737 | 4.593 | 3.400 |
| 5 | 4.957 | 6.373 | 5.820 | 4.897 | 3.520 | 4.780 | 4.593 | 5.077 |
| 6 | 3.290 | 5.030 | 7.620 | 5.043 | 6.457 | 6.737 | 7.597 | 6.630 |

To measure the efficiency based on the proposed approach in the previous section, the data of six Iranian oil companies presented in Tables 4, 5, and 6 were used. To achieve this objective, Eqs. (1), (2), (3), and (4) presented in Section 3, were utilized. Since the calculated efficiency for most companies is equal to one, two virtual DMUs were considered: a DMU with the best performance and another with the worst performance in each stage. This is because all DMUs (units with efficiency score equal to one) should be ranked according to their performance.

## 6. Results and discussion

This paper introduced an integration of the two most famous models for the measurement of an organization's efficiency: the DEA and BSC models. A three-stage DEA-based approach was developed to compute the efficiency of six oil companies in Iran. The calculated efficiency scores are presented in Table 7. The GAMS software was utilized for the calculation of these efficiency scores.

From Table 7, it can be observed that the efficiency of Stage 3 related to Company 6 is equal to 1.000 but the overall efficiency score is 0.717 because of the weak performance of this company in stages 1 and 2 with 0.758 and 0.762, respectively. As a result, the overall efficiency remained at 0.717. Therefore, the total efficiency was influenced by the inefficiencies of stages 1 and 2. It must be mentioned that based on our proposed approach, an output of one stage serves as input for the next stage and when the efficiency of one stage is equal to 1.000, it cannot necessarily be said that the related DMU performs efficiently because the performance of the mentioned DMU in other stages can be low. Also, the result observed from DMU 6 proved that the profitability of an organization does not necessarily indicate an organization's efficient performance. Hence, its performance must be investigated from different aspects. The results revealed that the most efficient unit in Stage 1 is Company 1 while the lowest efficiency score in this stage was obtained by Company 4. In Stage 2, the highest efficiency score was recorded by Company 5 while the lowest efficiency score was produced by Company 6. Ultimately, Company 6

**Table 7.** Efficiency score of the proposed approach.

| Company | Stage1 | Stage2 | Stage3 | Total |
|---|---|---|---|---|
| 1. National Iranian South Oil Company | 0.991 | 0.815 | 0.722 | 0.790 |
| 2. Khazar Oil Exploitation and Production Company | 0.950 | 0.832 | 0.935 | 0.768 |
| 3. Pars Oil and Gas Company | 0.931 | 0.961 | 0.633 | 0.730 |
| 4. Aravindan Oil & Gas Company | 0.742 | 0.911 | 0.611 | 0.684 |
| 5. Iranian Offshore Oil Company | 0.770 | 0.995 | 0.766 | 0.733 |
| 6. National Iranian Central Oil Company | 0.758 | 0.762 | 1.000 | 0.717 |

is the most efficient unit in Stage 3 while Company 4 has the lowest efficiency. In terms of total efficiency, companies 1 and 4, respectively, had the highest and the lowest efficiency scores. The efficiency scores are presented in Fig. 5, so as to to facilitate the comparison of scores obtained in each stage as well as the overall efficiency score.

Table 8 shows the average efficiency of all companies in each stage. It can be seen that Stage 2 has the highest rate of efficiency which reflects the good performance of companies in the internal perspective, as well as their high capability for implementation of variable resources in this performance perspective.

**Table 8.** Average efficiency of companies in 3 stages

| Stage | Average efficiency score |
|---|---|
| 1 | 0.857 |
| 2 | 0.879 |
| 3 | 0.777 |

It appears that most companies recorded their best performance in Stage 2 and their worst one in Stage 3. There is need to enhance their capabilities in order to better utilize their current resources in customers' perspectives.

## 7. Conclusion

Economic development, prosperity and the life styles of developed communications are built on energy. Oil and gas are the principal source of energy [25], despite significant efforts to create diversity in it. Iran's economy is heavily dependent on industry such that oil supplies a major part of the country's budget. In order to improve the function of this industry, its performance evaluation seems necessary, this is because you cannot improve what you cannot measure. In this study, the authors proposed a new approach for evaluating the performance of six oil companies in Iran, using the integrated BSC and DEA models. In the studies conducted so far on the integration of BSC and DEA methods, the BSC structure was embedded in separate DEA models or four-stage DEA models while the proposed approach in this study employed a three-stage model. At first, with regard to the causal linkage among BSC's aspects, the related input/ output variables of each stage were selected. Afterwards, the efficiency score of all stages was calculated as well as the total score. The results revealed that the National Iranian South Oil Company, Iranian Offshore Oil Company, and National Iranian Central oil company are the most sufficient companies in stages 1, 2, and 3, respectively. The lowest efficiency score of stages 1 and 3 was obtained by Aravindan Oil & Gas Company while that of Stage 2 is related to the National Iranian Central Company; in terms of total efficiency scores, the National Iranian South Oil Company and Aravindan Oil & Gas Company, respectively, recorded the highest and lowest efficiencies. Also, the results proved that a company is sufficient if its performance is efficient in all stages. The approach presented in this study is a worthwhile and beneficial tool to oil companies' managers, in order to recognize the areas of strength and weakness of their companies. Also, this approach can help decision makers in other industries and firms. Having evaluated the performance, the firms' managers should detect the process and procedures which resulted to performance improvement.

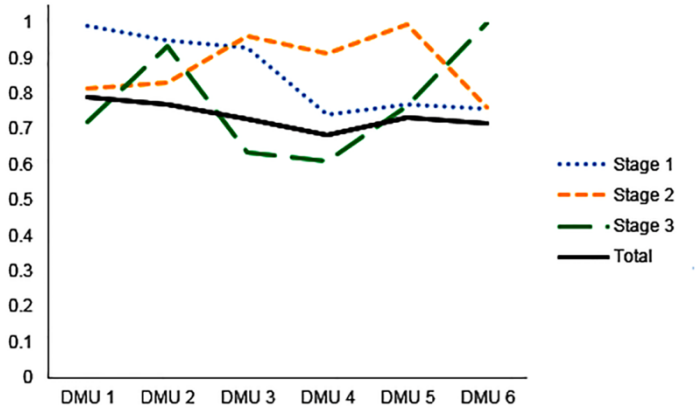


**Fig. 5.** Efficiency scores of six oil companies

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