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Implementing Fuzzy DEA into the PEM Model for Performance Evaluation of Project-Based Organizations: A case study

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Abstract

Project-based organizations in upstream industries hold a large share of national resources and play an important role in the development of a country. Performance evaluation of project-based organizations can help managers to use inputs effectively and smooth their way to achieving goals. There are many qualitative and quantitative indices to performance evaluation of project-based organizations. Efficiency calculation through Data Envelopment Analysis (DEA) is a common index for performance assessment in such firms. In the traditional DEA model crisp data is needed while, in the real world, most of the data are imprecise and uncertain. A major cause of uncertainty related to the non-quantifiable, incomplete, and unachievable information that caused fuzzy logic and fuzzy sets merge in different models like DEA. The main idea of the present study is to combine quantitative and qualitative approaches in performance appraisal to take advantage of both and achieve more accurate results; therefore, in this paper, a hybrid model based on Fuzzy Data Envelopment Analysis (FDEA) and Project Excellence Model (PEM) is proposed for performance evaluation in project-based organizations. First, performance assessment by the PEM model of Fuzzy data is accomplished. Then, implementing Fuzzy DEA into the PEM model is performed in which the inputs and outputs of the FDEA model are the PEM model criteria. The proposed hybrid model is used to evaluate 30 petrochemical companies in Iran. The comparison of the results of both models indicates a correlation coefficient of almost 0.90 at the significance level of 0.01 that shows an appropriate correlation between the two models.

Keywords:
Fuzzy Data Envelopment Analysis (FDEA)
Project Excellence Model (PEM)
Efficiency Analysis
Petrochemical Industry
Petro-Chem Supply Chain
Project Management

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INTRODUCTION

Organizational efforts to achieve a comprehensive evaluation model and complement traditional methods have been ongoing for years. This path has led to the introduction of business excellence models and national quality awards, including the Malcolm Baldrige Award Model (Steel, 2016) and the European Foundation for Quality Management framework (EFQM team, 2013). At first glance, comparing the projects of a company with each other seems very difficult because each project is a unique endeavor, but from a systematic perspective, (in most cases) projects are made up of similar components that can be practically compared. The International Project Management Association (IPMA) uses a model called Project Excellence Model (PEM) to evaluate projects. It is adapted from the EFQM model and developed for project excellence including key indicators of project success. For the first time, in 1997, the German Project Management Association (GPM) developed the project excellence model and used it as a tool to evaluate candidates and choose the annual German Project Management Awards (GPM, 2014; IPMA, 2016). Since 2002, besides updates, this model has been the basis for international project management awards in more than 50 countries (Grau, 2011). The PEM model has attracted the attention of researchers as a tool for quality management (Kwak et al., 2015; Cooney, 2020) due to its outstanding credibility and usability. There is much empirical evidence for the implementation of this model and validity of its criteria in various areas of business (Westerveld, 2003; Jaafari, 2007; Obradović et al., 2016). The majority of such studies quantify categories in a multidimensional fashion to demonstrate the value and benefits of the PEM. The effort of companies to improve is a continuous exercise, and has remained even in recent years despite the global evolutions, as project-oriented organizations have tried to adapt to excellence models (Bushuyev and Verenych, 2018; Yu, 2019).

Data Envelopment Analysis (DEA) is one of the significant branches of operations research science and was originally proposed by Charnes, Cooper, and Rhodes (1978); this version of the model now known by the acronym CCR. DEA is a non-parametric programming technique for efficiency evaluation in a group of homogenous Decision-Making Units (DMUs) with multiple inputs and multiple outputs (Moghaddas et al., 2021; Sueyoshi et al., 2020; Henriques et al., 2020). The primary CCR model is applied globally only to technologies characterized by Constant Returns to Scale (CRS). That is why Banker, Charnes, and Cooper (1984) developed the model for Variable Return to Scale (VRS) technologies and introduced the BCC version. This version admits the VRS and distinguishes between technical inefficiencies and scale (Díaz and Sanchez-Robles, 2020).

Most methods of ranking DMUs assume that input and output data measures precisely, however, the determined values of input and output data are often vague. Inaccurate evaluations are also the results of unquantifiable, incomplete, and non-obtainable data. In general cases the data for analysis evaluation are usually collected from investigations that include natural language signs such as "Excellent", "Average", and "Poor" rather than a particular value and the reason why the inputs and outputs are "Fuzzy". Fuzzy logic (Lotfizadeh, 1965) is an approach that has played an essential role in the analysis of ambiguous and uncertain data in various branches of science. Today, many industrial and applied quantitative studies are conducted using fuzzy logic. In the real world, since individuals understand and apply many concepts in the ‘fuzzy’ way (meaning inaccurate, vague, and ambiguous), fuzzy logic is an efficient approach to dealing with the increasing complexities of studying, analyzing, modeling, and problem solving. Fuzzy approaches have also been used in the data envelopment analysis literature. Cooper et al. (1999) were the first to propose a solution for managing imprecise data in the DEA. Kao and Liu (2000), Guo and Tanaka (2001), and Lertworasirikul et al. (2003, 1) have been among the pioneers in implementing fuzzy logic in data envelopment analysis.

Data fuzzification in envelopment analysis is different from statistical probability. Although the possibility measure has been widely used it has no self-duality property, however, a self-dual measure is completely required in each theory and practice. To define a self-dual measure, Kao and Liu (2003) presented the idea of credibility measure and an axiomatic foundation of credibility theory (Kao and Liu, 2003; Matin and Azizi, 2015). In this study, the credibility measure is employed to the fuzzy DEA model. The applications of fuzzy set theory in DEA are sometimes categorized into the following classifications: The tolerance approach (Sengupta, 1992), the α-Level based approach (Hatami-Marbini et al., 2011), the fuzzy ranking approach (Guo and Tanaka, 2001), and the possibility approach (Lertworasirikul et al., 2003, 2).The petrochemical industry was chosen as a case study of project-oriented companies due to the inherent value creation of this industry and its emerging challenges. Today, the petrochemical industry is facing pressures such as competitive global prices, the need to reduce costs, prevent environmental pollution, and improve and integrate the supply chain which identifies the need for horizontal and vertical optimization (Li, 2016). Despite numerous fossil energy sources in the Persian Gulf region and close competition, improving the productivity of petrochemical companies in West Asian countries must be twofold.

While qualitative methods have disadvantages such as ambiguity in definition of criteria and the relativity of participant responses, quantitative methods create a reduction in the reality that may cause a defect in expressing the problem situation. In addition to utilizing the advantages of both approaches, the limitations of each can be overcome to some extent by combining qualitative and quantitative approaches. A hybrid model both approximately covers the intersubjective definitions of indicators as well as provides specific estimates for measurement and comparison. This study aims to combine the qualitative project excellence model with fuzzy data envelopment analysis and then implement the composite model for 30 companies in the petrochemical industry.

MATERIALS METHODS

Project Excellence Model

The basis of the project excellence model is the EFQM excellence model (EFQM team, 2013) introduced by the European Foundation for Quality Management in the late 1980s creating many awards and competitions in the field of performance appraisal and organizational excellence at the national and international levels. Different versions of this model and its derivatives (including PEM) give managers a valid and structured framework of what needs to be measured (Hidiroğlu, 2019). The PEM model provides a multidimensional analysis of the status of a project by measuring criteria. This model consists of nine criteria in two main parts: Project management and project results. The share of each part of the total score (project excellence) is half. The schematic model is shown in Fig. 1.

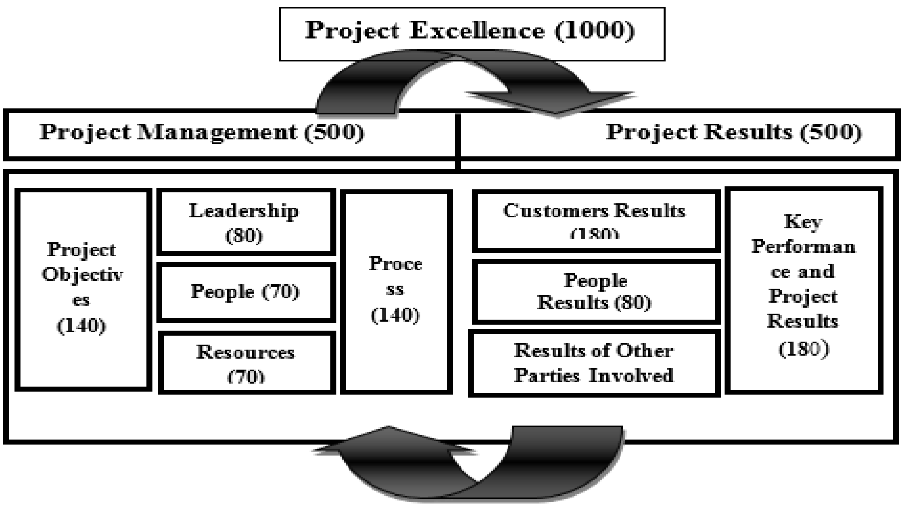

Fig.1. Project Objectives

Criterion 1: Project Objectives

This criterion shows how project objectives are developed and implemented, despite the various stakeholder expectations, and the sheer volume of relevant data.

- How the expectations and demands of beneficiaries are measured
- How to measure project objectives and how to integrate conflicting competitive interests
- How project objectives are being customized and communicated

Criterion 2: Leadership

This criterion shows how the behavior of managers while supporting the project induces and develops project excellence.

- All managers represent a reliable example of project excellence and with their support promote project progress.
- Project managers pay attention to suppliers, customers, and the project supply chain in general.

Criterion 3: People

This criterion shows how the project team members act as a unit and their capacities are seen and used in the team.

- Outputs and outcomes of the project are presented by individuals and their desired work habits are maintained.
- Project workers and employees participate in project activities despite being allowed to take independent actions.

Criterion 4: Resources

This criterion shows how to use existing resources effectively and efficiently.

- How financial resources are budgeted in project plans
- How project data is organized and managed
- How project is planned
- How project uses the services of suppliers in the supply chain
- How alternative resources are considered in the project framework

Criterion 5: Processes

This criterion shows how the critical processes of project units are identified and adjusted as necessary.

- Project processes should be constantly reviewed, checked, customized, and optimized as needed.
- Indicates the degree of compatibility of project strategies and project management systems and aims to improve effectiveness
- Emphasizes that there should be a routine in the project that documents past and present experiences in order to create knowledge values in addition to financial gain

Criterion 6: Customers Results

This criterion shows what the project achieves regarding client expectations and satisfaction.

- Describes how customers choose the project based on its results and achievements (This statement should be modified for different stakeholders.)
- States what measures customers choose the project according to and what the differences are between various groups of customers

Criterion 7: People Results

This criterion reflects what the project achieves in terms of employee expectations and satisfaction.

- How managers, employees, and workers choose the project, collaborate within the project, and consequently benefit from its results and achievements
- How managers, employees, and workers evaluate project outputs

Criterion 8: Results of Other Parties Involved

This criterion shows what the project achieves regarding the expectations of other interested parties.

- How opposing parties perceive their loss from the project and how the various parties differ concerning the project

Criterion 9: Key Performance and Project Results

This criterion represents the results of the project according to the expected measures and key performance indicators.

- Rate of achievement of goals
- Project performance measurement is discussed

Many studies have used the PEM framework to develop the literature on project management and project excellence, and also many essays have been published with a practical approach to applying the PEM model to project evaluation across the world. These include Westerveld (2003) in critical PEM indicators, Jaafari (2007) in project diagnostics, Kwak et al. (2015) in the project-based organizations maturity, Obradović et al. (2016) in project management rethinking, and Szabó (2016) in innovative and sustainable project management.

DEA and FDEA

leading organizations have always paid special attention to both efficiency and effectiveness indicators and try to measure both of them (Lotfi et al., 2020); In this way, the DEA model was developed by Charnes et al. (1978) and uses applied linear programming for comparative evaluation of DMUs efficiencies. The purpose of data envelopment analysis is to examine a certain number of decision-making units that perform the same tasks, although they differ in the number of inputs used and the outputs generated. Conventional DEA models are often built on some basic information about returns to scale assumptions such as constant or variable return to scale for the underlying production set (Moghaddas et al., 2022) and it should be noted that Since the presentation of the first DEA models, different modifications from variety of aspects have been provided to strengthen the power of DEA (Moghaddas et al., 2020). There are basically two classic DEA models: The CRS model (also called CCR) and the VRS model (also called BCC). The first type of model considers constant return to scale (Charnes et al., 1978), while the second type considers variable return to scale with no proportion between inputs and outputs (Banker et al., 1984).

The importance of fuzzy computing in data envelopment analysis is determined by the fact that the entry data to the CCR and BCC models are assumed to be accurate numerical values, while the observed value of inputs and outputs is often inaccurate and ambiguous (Babazadeh et al., 2020).

Emrouznejad and Tavana (2014), in their book, offer a classification of DEA fuzzy methods based on studies and articles published in authoritative scientific sources, which includes the following 7 categories:

- The Tolerance Approach
- The α-Level Based Approach
- The Fuzzy Ranking Approach
- The Possibility Approach
- The Fuzzy Arithmetic
- The Fuzzy Random
- Type-2 Fuzzy Set

Although the formation of fuzzy data envelopment analysis dates back to Sengupta calculations in 1992 (Sengupta, 1992), today FDEA is widely used to evaluate the performance of various industrial areas. Studies of Babazadeh et al. (2020) in evaluating the performance of renewable power sources, Chen et al. (2020) in selecting the intelligent product service systems, Pambudi and Nananukul (2019) in feasibility study of wind turbines, and Rezaee et al. (2018) in predicting information of the stock exchange are just some of the new uses for FDEA.

In this study, to utilize the DEA model after some mathematical methods, the model is rewritten yielding a linear programming problem (LPP) which is shown in model 1.

$$
\begin{aligned}
&\text{MAX } Z_0 = \sum_{r=1}^{s} u_r y_{r0} \qquad o \in \{1,2,\dots,n\} \\
&\text{St.} \\
&\sum_{i=1}^{m} v_i x_{i0} = 1 \quad (i = 1, 2, \dots, m) \\
&\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \quad (j = 1, 2, \dots, n) \\
&u_r \ge 0, v_i \ge 0 \quad r = (1, 2, \dots, s)
\end{aligned} \tag{1}
$$

In this model, u_r is the weight of r^{th} output; v_i is the weight of i^{th} input; and o is the index of the considered DMU. y_{ro} and x_{io} are also the value of r^{th} output and i^{th} input of the considered DMU (unit o). y_{rj} and x_{ij} are the values of r^{th} output and i^{th} input for the j^{th} unit, respectively. s is the number of outputs; m is the number of inputs; and n is the number of decision making units.

Since there is one solved LLP for each DMU, if n DMUs exist, then n LLPs must be solved, with s^{+}_{r}

variables. The model, simply given, is the basis for all other DEA models.

FDEA-PEM MODEL

As mentioned earlier, the PEM model evaluates project success based on a set of project management enablers and a set of defined outcomes. In this study, by adapting the inputs of the DEA model with management enablers and the outputs of the DEA model with the project results, a model for evaluating project-based organizations is presented; seen in Figure 2. First, the score of the enablers and the results are calculated by the total weighting method, then the score of the enablers is considered as input and the score of the results is considered as output.

The Inputs include Project Objectives (denoted by x_1), Leadership (x_2), People (x_3), Resources (x_4), Process (x_5), and the Outputs include Customers Results (denoted by y_1), People Results (y_2), Results of Other Parties Involved (y_3), and Key Performance and Project Results (y_4).

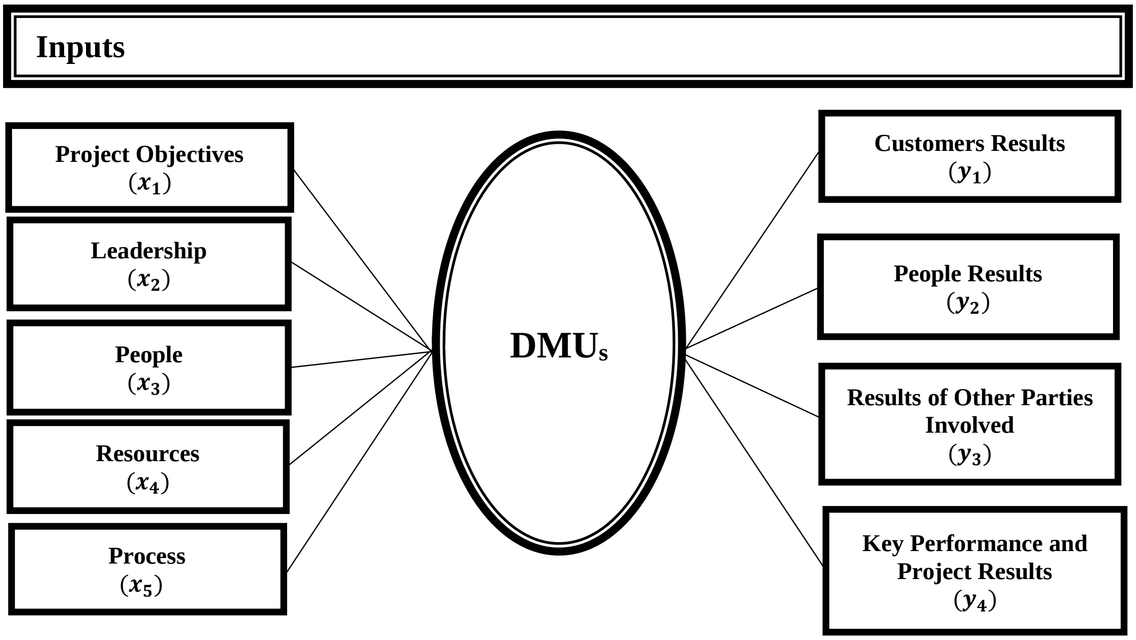

Fig. 2. The schematic structure of DEA-PEM model

Thus, the optimal weights are considered for each of the elements. The best way to determine the value of each input and output element is to use a standard PEM questionnaire. After distributing the questionnaire among the participants in the project excellence plan, and their completing the questionnaire, these questionnaires are collected and the raw score of each indicator is calculated.

The modeling was carried out as follows:

Assuming we have n DMUs, the i[th] unit of each uses a vector of 5 inputs called x_{ij} and a vector of 4 outputs called y_{ij}. A triangular fuzzy number (E) is usually represented by triple numbers (E^l, E^m, E^u). Due to this assumption, model 1 can be rewritten as model 2.

$$
\begin{aligned}
& MaxE_p = \sum_{r=1}^{s} u_r \tilde{y}_{rp} \\
& subject\ to: \\
& \sum_{i=1}^{m} v_i \tilde{x}_{ip} = 1 \\
& \sum_{r=1}^{s} u_r \tilde{y}_{rj} - \sum_{i=1}^{m} v_i \tilde{x}_{ij} \le 0 : \forall j \in \{1,2,\dots,n\} \\
& v_i, u_r \ge 0 : \forall r \in \{1,2,\dots s\}, \forall i \in \{1,2,\dots,m\}
\end{aligned} \qquad (2)
$$

$\tilde{y}_{rj}$ is amount of output r produced and $\tilde{x}_{ij}$ is amount of input i produced by DMU_j, $\tilde{\theta}_p$ is fuzzy performance of DMU_p. V_i is weight given to input i; u_r is the weight given to the output r, and symbol "~" indicates the fuzzy value. The fuzzy number $\tilde{E}$ can be written as (E^l, E^m, E^u). Then, model 2 can be modified to model 3.

$$Max(E_p^l, E_p^m, E_p^u) = \sum_{r=1}^{s} u_r\,(y_{rp}^l, y_{rp}^m, y_{rp}^u)$$

$subject\ to$:

$$\sum_{i=1}^{m} v_i\,(x_{ip}^l, x_{ip}^m, x_{ip}^u) = 1$$

$$\sum_{r=1}^{s} u_r\,(y_{rp}^l, y_{rp}^m, y_{rp}^u) - \sum_{i=1}^{m} v_i\,(x_{ip}^l, x_{ip}^m, x_{ip}^u) \le 0; \forall j \in \{1, 2, \dots, n\}$$

$$v_i, u_r \ge 0; \quad \forall r \in \{1, 2, \dots, s\}, \forall i \in \{1, 2, \dots, m\}$$

(3)

For defuzzification of fuzzy values the area center method is used. The area center calculation for defuzzification can be obtained from formula 1. Point ME_{ij}, called the mean and LE_{ij} UE_{ij}, are the right hand and left hand of M, respectively. CA_{ij} is also the area center formula.

$$CA_{ij} = [(UE_{ij}-LE_{ij}) + (ME_{ij}-LE_{ij})]/3 + LE_{ij}$$

Formula 1

CASE STUDY

In order to test the proposed model, the required data were collected from 30 companies (DMUs) based on the standard PEM model questionnaire. These companies are active in the Iranian petrochemical industry and the questionnaire was completed in joint meetings by middle and senior managers. The management teams had the essential expertise in the field of project success evaluation and organizational excellence. Relevant data can be seen in Table 1.

Table 1: The gathered information of PEM model

DMUs	(x_1) 140	(x_2) 80	(x_3) 70	(x_4) 70	(x_5) 140	(y_1) 180	(y_2) 80	(y_3) 60	(y_4) 180
DMU1	(56,70,84)	(48,56,64)	(28,35,42)	(42,49,56)	(56,70,84)	(36,54,72)	(32,40,48)	(24,30,36)	(36,54,72)
DMU2	(28,42,56)	(48,56,64)	(56,63,70)	(42,49,56)	(28,42,56)	(36,54,72)	(48,56,64)	(36,42,48)	(36,54,72)
DMU3	(56,70,84)	(48,56,64)	(56,63,70)	(28,35,42)	(28,42,56)	(36,54,72)	(48,56,64)	(48,54,60)	(36,54,72)
DMU4	(28,42,56)	(16,24,32)	(14,21,28)	(14,21,28)	(28,42,56)	(36,54,72)	(16,24,32)	(24,30,36)	(36,54,72)
DMU5	(28,42,56)	(32,40,48)	(42,49,56)	(42,49,56)	(28,42,56)	(0,18,36)	(16,24,32)	(24,30,36)	(36,54,72)
DMU6	(28,42,56)	(32,40,48)	(28,35,42)	(28,35,42)	(28,42,56)	(0,18,36)	(32,40,48)	(24,30,36)	(36,54,72)
DMU7	(28,42,56)	(32,40,48)	(42,49,56)	(42,49,56)	(28,42,56)	(36,54,72)	(32,40,48)	(36,42,48)	(36,54,72)
DMU8	(56,70,84)	(48,56,64)	(42,49,56)	(42,49,56)	(28,42,56)	(36,54,72)	(32,40,48)	(36,42,48)	(36,54,72)
DMU9	(28,42,56)	(48,56,64)	(42,49,56)	(28,35,42)	(28,42,56)	(36,54,72)	(32,40,48)	(36,42,48)	(36,54,72)
DMU10	(28,42,56)	(32,40,48)	(28,35,42)	(28,35,42)	(28,42,56)	(0,18,36)	(32,40,48)	(36,42,48)	(36,54,72)
DMU11	(28,42,56)	(32,40,48)	(42,49,56)	(42,49,56)	(28,42,56)	(36,54,72)	(32,40,48)	(36,42,48)	(36,54,72)
DMU12	(56,70,84)	(48,56,64)	(42,49,56)	(42,49,56)	(28,42,56)	(36,54,72)	(48,56,64)	(36,42,48)	(36,54,72)
DMU13	(56,70,84)	(48,56,64)	(56,63,70)	(56,63,70)	(28,42,56)	(36,54,72)	(32,40,48)	(48,54,60)	(36,54,72)
DMU14	(56,70,84)	(48,56,64)	(56,63,70)	(56,63,70)	(28,42,56)	(36,54,72)	(32,40,48)	(36,42,48)	(36,54,72)
DMU15	(28,42,56)	(48,56,64)	(28,35,42)	(28,35,42)	(28,42,56)	(36,54,72)	(32,40,48)	(36,42,48)	(36,54,72)
DMU16	(28,42,56)	(48,56,64)	(42,49,56)	(42,49,56)	(28,42,56)	(0,18,36)	(32,40,48)	(36,42,48)	(36,54,72)
DMU17	(56,70,84)	(48,56,64)	(42,49,56)	(42,49,56)	(56,70,84)	(36,54,72)	(32,40,48)	(36,42,48)	(36,54,72)
DMU18	(56,70,84)	(48,56,64)	(42,49,56)	(42,49,56)	(56,70,84)	(36,54,72)	(32,40,48)	(36,42,48)	(36,54,72)
DMU19	(28,42,56)	(16,24,32)	(28,35,42)	(28,35,42)	(0,14,28)	(0,18,36)	(0,8,16)	(24,30,36)	(0,18,36)
DMU20	(28,42,56)	(32,40,48)	(28,35,42)	(28,35,42)	(28,42,56)	(0,18,36)	(16,24,32)	(24,30,36)	(0,18,36)

DMU21	(28,42,56)	(48,56,64)	(42,49,56)	(42,49,56)	(28,42,56)	(36,54,72)	(32,40,48)	(36,42,48)	(36,54,72)
DMU22	(28,42,56)	(32,40,48)	(56,63,70)	(42,49,56)	(28,42,56)	(36,54,72)	(32,40,48)	(48,54,60)	(36,54,72)
DMU23	(28,42,56)	(16,24,32)	(28,35,42)	(28,35,42)	(28,42,56)	(36,54,72)	(32,40,48)	(36,42,48)	(36,54,72)
DMU24	(56,70,84)	(64,72,80)	(42,49,56)	(42,49,56)	(28,42,56)	(36,54,72)	(32,40,48)	(36,42,48)	(36,54,72)
DMU25	(56,70,84)	(48,56,64)	(42,49,56)	(42,49,56)	(56,70,84)	(36,54,72)	(32,40,48)	(36,42,48)	(36,54,72)
DMU26	(28,42,56)	(32,40,48)	(42,49,56)	(14,21,28)	(28,42,56)	(0,18,36)	(16,24,32)	(36,42,48)	(0,18,36)
DMU27	(28,42,56)	(32,40,48)	(28,35,42)	(28,35,42)	(28,42,56)	(0,18,36)	(32,40,48)	(24,30,36)	(36,54,72)
DMU28	(28,42,56)	(32,40,48)	(42,49,56)	(42,49,56)	(28,42,56)	(0,18,36)	(16,24,32)	(36,42,48)	(36,54,72)
DMU29	(56,70,84)	(48,56,64)	(56,63,70)	(42,49,56)	(28,42,56)	(36,54,72)	(32,40,48)	(48,54,60)	(36,54,72)
DMU30	(28,42,56)	(48,56,64)	(42,49,56)	(42,49,56)	(28,42,56)	(36,54,72)	(32,40,48)	(36,42,48)	(36,54,72)

The data obtained from the questionnaire include five enable criteria as inputs and four result criteria as outputs. The PEM model determines a specific weight for each criterion and then aggregates the sum of the criteria weights to obtain the final score.
However, in the proposed model of this study, different weight is required for each criterion. In the normal evaluation of the PEM model, the larger the data, the more efficient the project. In the DEA model, smaller input data correlates positively with greater company performance. For this reason, in the hybrid model, the enabler data that is the input is inverted and subtracted from 1 then used in the model. In Table 2, data of the inputs and outputs of the FDEA model are presented by inverting the inputs.

Table 2: Data on the inputs and outputs of FDEA by inverting inputs

DMU$_s$	(x_1)	(x_2)	(x_3)	(x_4)	(x_5)	(y_1)	(y_2)	(y_3)	(y_4)
DMU1	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.6,0.5,0.4)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.4,0.5,0.6)	(0.2,0.3,0.4)
DMU2	(0.8,0.7,0.6)	(0.4,0.3,0.2)	(0.2,0.1,0.0)	(0.4,0.3,0.2)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU3	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.2,0.1,0.0)	(0.6,0.5,0.4)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.6,0.7,0.8)	(0.8,0.9,1.0)	(0.2,0.3,0.4)
DMU4	(0.8,0.7,0.6)	(0.8,0.7,0.6)	(0.8,0.7,0.6)	(0.8,0.7,0.6)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.2,0.3,0.4)
DMU5	(0.8,0.7,0.6)	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.8,0.7,0.6)	(0.0,0.1,0.2)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.2,0.3,0.4)
DMU6	(0.8,0.7,0.6)	(0.6,0.5,0.4)	(0.6,0.5,0.4)	(0.6,0.5,0.4)	(0.8,0.7,0.6)	(0.0,0.1,0.2)	(0.4,0.5,0.6)	(0.4,0.5,0.6)	(0.2,0.3,0.4)
DMU7	(0.8,0.7,0.6)	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU8	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU9	(0.8,0.7,0.6)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.6,0.5,0.4)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU10	(0.8,0.7,0.6)	(0.6,0.5,0.4)	(0.6,0.5,0.4)	(0.6,0.5,0.4)	(0.8,0.7,0.6)	(0.0,0.1,0.2)	(0.4,0.5,0.6)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU11	(0.8,0.7,0.6)	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU12	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.2,0.3,0.4)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU13	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.2,0.1,0.0)	(0.2,0.1,0.0)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.8,0.9,1.0)	(0.2,0.3,0.4)
DMU14	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.2,0.1,0)	(0.2,0.1,0.0)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU15	(0.8,0.7,0.6)	(0.4,0.3,0.2)	(0.6,0.5,0.4)	(0.6,0.5,0.4)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU16	(0.8,0.7,0.6)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.8,0.7,0.6)	(0.0,0.1,0.2)	(0.4,0.5,0.6)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU17	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.6,0.5,0.4)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU18	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.6,0.5,0.4)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU19	(0.8,0.7,0.6)	(0.8,0.7,0.6)	(0.6,0.5,0.4)	(0.6,0.5,0.4)	(1.0,0.9,0.8)	(0.0,0.1,0.2)	(0.0,0.1,0.2)	(0.4,0.5,0.6)	(0.0,0.1,0.2)
DMU20	(0.8,0.7,0.6)	(0.6,0.5,0.4)	(0.6,0.5,0.4)	(0.6,0.5,0.4)	(0.8,0.7,0.6)	(0.0,0.1,0.2)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.0,0.1,0.2)
DMU21	(0.8,0.7,0.6)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU22	(0.8,0.7,0.6)	(0.6,0.5,0.4)	(0.2,0.1,0.0)	(0.4,0.3,0.2)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.8,0.9,1.0)	(0.2,0.3,0.4)
DMU23	(0.8,0.7,0.6)	(0.8,0.7,0.6)	(0.6,0.5,0.4)	(0.6,0.5,0.4)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU24	(0.6,0.5,0.4)	(0.2,0.1,0.0)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU25	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.6,0.5,0.4)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.6,0.7,0.8)	(0.2,0.3,0.4)

DMU26	(0.8,0.7,0.6)	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.8,0.7,0.6)	(0.8,0.7,0.6)	(0.0,0.1,0.2)	(0.2,0.3,0.4)	(0.6,0.7,0.8)	(0.0,0.1,0.2)
DMU27	(0.8,0.7,0.6)	(0.6,0.5,0.4)	(0.6,0.5,0.4)	(0.6,0.5,0.4)	(0.8,0.7,0.6)	(0.0,0.1,0.2)	(0.4,0.5,0.6)	(0.4,0.5,0.6)	(0.2,0.3,0.4)
DMU28	(0.8,0.7,0.6)	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.8,0.7,0.6)	(0.0,0.1,0.2)	(0.2,0.3,0.4)	(0.6,0.7,0.8)	(0.2,0.3,0.4)
DMU29	(0.6,0.5,0.4)	(0.4,0.3,0.2)	(0.2,0.1,0.0)	(0.4,0.3,0.2)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.8,0.9,1.0)	(0.2,0.3,0.4)
DMU30	(0.8,0.7,0.6)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.4,0.3,0.2)	(0.8,0.7,0.6)	(0.2,0.3,0.4)	(0.4,0.5,0.6)	(0.6,0.7,0.8)	(0.2,0.3,0.4)

After obtaining the data in Table 2, the performance of each of the 30 companies was calculated using the CCR multiple model. In this model, both input-oriented and output-oriented approaches will reach the same result. In this study, the input-oriented approach is used. The results of implementing the CCR multiple model are presented in Table 3.

As seen in Table 3, one of the ranking problems based on the FDEA model is that, simultaneously, several DMU performances have been equal to 1; hence, there is no possibility of ranking the efficient units. In this regard, in 1993, Andersen and Petersen proposed a method for ranking efficient units in which it is possible to determine the most efficient unit. In this method, the efficiency score can be greater than 1; thus, efficient units are rating as inefficient units. This procedure is called Andersen-Petersen in optimization literature (Andersen and Petersen, 1993; Cooper et al., 2007). In fact, in the AP (Andersen-Petersen) optimization method, the studied unit is removed from the evaluation, and this makes the assigned number of efficient units in the complete AP ranking model greater than 1, and thus ranking between efficient units is also possible. The results of AP method calculations and company rankings can also be seen in Table 3. It should be noted that in Table 3, the first ranking column is related to the PEM evaluation results, the second ranking column is related to the CCR multiple model, and the third ranking column shows the results obtained from the AP method.

Table 3: Performance evaluation using PEM model, CCR model ($\varepsilon = 0.001$), and Andersen- Petersen method

DMU$_s$	**Rating Data according to PEM**	**Rating according to PEM**	**Rank (Based on PEM)**	**Efficiency according CCR multiple model**	**Rank (Based on CCR multiple model)**	**Efficiency based on the Andersen-Petersen model**	**Rank (Based on AP model)**
DMU1	(358,458,558)	458	11	1.000	1	1.000	10
DMU2	(358,458,558)	458	10	1.000	1	1.166	4
DMU3	(384,484,584)	484	2	1.000	1	1.163	5
DMU4	(212,312,412)	312	27	0.714	24	0.714	24
DMU5	(248,348,448)	348	23	0.800	18	0.800	18
DMU6	(236,336,436)	336	25	0.714	25	0.714	25
DMU7	(312,412,512)	412	17	0.800	19	0.800	19
DMU8	(356,456,556)	456	12	0.999	1	0.999	1
DMU9	(314,414,514)	414	16	0.846	14	0.846	14
DMU10	(248,348,448)	348	24	0.714	26	0.714	26
DMU11	(312,412,512)	412	18	0.800	20	0.800	20
DMU12	(372,472,572)	472	8	1.000	1	1.266	3
DMU13	(396,496,596)	496	1	1.000	1	1.285	2
DMU14	(384,484,584)	484	3	0.999	12	0.999	12
DMU15	(300,400,500)	400	19	0.800	21	0.800	21
DMU16	(292,392,492)	392	20	0.846	15	0.846	15
DMU17	(384,484,584)	484	4	1.000	1	1.000	6
DMU18	(384,484,584)	484	5	1.000	1	1.000	7
DMU19	(124,224,324)	224	30	0.424	30	0.424	30
DMU20	(184,284,384)	284	29	0.51	29	0.51	29
DMU21	(328,428,528)	428	14	0.846	16	0.846	16
DMU22	(338,438,538)	438	13	0.999	13	0.999	13
DMU23	(268,368,468)	368	21	0.714	27	0.714	27

DMU24	(372,472,572)	472	9	1.000	1	2.999	1
DMU25	(384,484,584)	484	6	1.000	1	1.000	8
DMU26	(196,296,396)	296	28	0.737	23	0.737	23
DMU27	(236,336,436)	336	26	0.714	28	0.714	28
DMU28	(260,360,460)	360	22	0.800	22	0.800	22
DMU29	(382,482,582)	482	7	1.000	1	1.000	9
DMU30	(328,428,528)	428	15	0.846	17	0.846	17

Finally, a comparison between the ranking results based on PEM and FDEA (Andersen-Petersen) models is shown in Table 4.

Table 4: Comparison of company rankings based on PEM and FDEA models

DMU$_s$	**PEM model**	**FDEA (Andersen-Petersen model)**
DMU1	11	10
DMU2	10	4
DMU3	2	5
DMU4	27	24
DMU5	23	18
DMU6	25	25
DMU7	17	19
DMU8	12	1
DMU9	16	14
DMU10	24	26
DMU11	18	20
DMU12	8	3
DMU13	1	2
DMU14	3	12
DMU15	19	21
DMU16	20	15
DMU17	4	6
DMU18	5	7
DMU19	30	30
DMU20	29	29
DMU21	14	16
DMU22	13	13
DMU23	21	27
DMU24	9	1
DMU25	6	8
DMU26	28	23
DMU27	26	28
DMU28	22	22
DMU29	7	9
DMU30	15	17

A comparison of the results of both models using the Spearman rank correlation indicates a correlation coefficient of 0.90 at a significance level of 0.01. Given the correlation coefficient, there is close adjustment and alignment between the results of these two models.

The findings of this study indicate that a hybrid model based on fuzzy data envelopment analysis (FDEA) and project excellence model (PEM) can be performed to evaluate performance in project-based organizations. In this method, first, the performance evaluation was performed by the fuzzy data for PEM model and then the fuzzy DEA implementation was performed in the PEM model. In other words, in this method, the inputs and outputs of the FDEA model are the criteria of the PEM model. The proposed hybrid model has been used to evaluate 30 petrochemical companies. According to the findings obtained in Table 3 and Table 4, 20 petrochemical companies have efficiencies below 1, of which 8 units DMU4, DMU6, DMU10, DMU19, DMU20, DMU23, DMU26, DMU27 have efficiencies less than 0.80. According to the research findings, two units, DMU19 and DMU20, have a critical performance status, in which the senior managers of the company can see the reasons for the low efficiency of these units in Table 1 and Table 2, separately for each component. In other words, weakness in one or more factors of the project excellence model has caused these problems; Factors such as project objectives, leadership, staff (people), resources, processes, as well as project outcome metrics include customer outcomes, employee (people) outcomes, outcomes of other parties, and key performance outcomes and project results.

CONCLUSION

PEM and FDEA models are two important tools for measuring organizational performance and project excellence. The main basis of the PEM model is the EFQM Excellence Model, which forms the framework of international business excellence awards. The PEM model measures improvement criteria qualitatively while the DEA model is a non-parametric programming method for evaluating the performance of a group of homogeneous DMUs with multiple inputs and multiple outputs. Performance assessment using DEA needs accurate and crisp values for inputs and outputs, but in many cases in the real world, data are inaccurate and ambiguous. To overcome this limitation, the fuzzy set approach has been used in this study. One of the main disadvantages of the PEM model is that it similarly sets the same default values for all companies which can be addressed by evaluating decision units separately in a system such as FDEA. While quantitative research tools in the social and behavioral sciences (such as management) take a deductive and piecemeal approach and allow accurate analysis by reducing real data, qualitative tools are scrutinizing and exploratory and interpret the phenomenon (Zawawi, 2007). Although fuzzy data envelopment analysis attributes to only a set of numbers in a predefined format to unit performance, the PEM framework can provide a more comprehensive description of the project performance status. The main achievement of this research was to compare the combination of the FDEA mathematical model with the PEM conceptual model, which forms a conceptual/mathematical model. The proposed hybrid model can be considered an improved optimization method that helps assessment and benchmarking in the complex industrial ecosystem of today.

In the next step, a case study in the Iranian petrochemical industry was presented to prove the applicability of the proposed model. Performance evaluation was implemented in the framework of PEM and by fuzzy data so that the inputs and outputs of the FDEA model were the criteria of the PEM model. A comparison of the results of both models shows a correlation coefficient of approximately 0.90 at a significance level of 0.01 which indicates a good correlation between these two models. One of the main limitations of this study was the difficult access to the entire target community due to their wide dispersion and also the reluctance or some caution of some units in completing the distributed questionnaire. There are also some general limitations to fuzzy computing in this study. It is recommended to Iran Petrochemical Company to carefully examine the units that have had weak ranks in terms of efficiency (especially ranks above 10) according to the points obtained by each unit in the 9 components; Discover the reasons for low efficiency and take action to remove concerning obstacles.In this study, the researchers showed that the proposed model can be used efficiently to evaluate companies and its application was approved by a case study. Other researchers may integrate other optimization methods and offer similar approaches in future studies. Researchers are advised to use the fuzzy data envelopment analysis model in combination with other performance evaluation models appropriate to their studied organization. It is also recommended to design the native model of organizational performance evaluation following the ecosystem of the studied organizations, and finally to implement it by using mathematical and statistical methods.

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