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A Model for Project Manager Competence Measurement in Iran Gas Engineering and Development Company

Mohammad Ali Hatefi [1,*], Samaneh Behi [1]

[1] Department of Energy Economics and Management, Petroleum University of Technology, Tehran, Iran.
Emails: hatefi@put.ac.ir; behi.s@put.ac.ir.

* Correspondence: hatefi@put.ac.ir.

Abstract: The purpose of this study is to build a Project Manager Competence Development (PMCD) model for Iran Gas Engineering and Development Company (IGEDC). The existent competence models in the related state-of-the-art are reviewed to generate and compile an initial list of project managers' competencies. Then, a Delphi analysis is used to complete the list and validate it. Further, the Best Worst Method (BWM) is employed to assign numerical weights to the competencies. As a result of the study, 16 competencies were identified in two categories: technical and behavioral. To show the applicability of the proposed PMCD, it is applied in a real-life study case. The results showed: (1) leadership competence has the highest weight, and (2) this fact that more than 99% of the total weight concerns only three competencies: leadership, project management knowledge, and judgment & decision making.

Keywords: Project Management; Project Manager Competence Development; Iran Gas Engineering and Development Company; BWM; Delphi; Affinity Diagram.

1. Introduction

Let's start with a brief introduction to Iran Gas Engineering and Development Company (IGEDC). The IGEDC is a growing and pioneer organization in the management and implementation of so many gas industry programs and projects. Accordingly, project management in this industry is very important. Project managers can perform better if their competencies and personal characteristics fulfill the demands of the job position [1]. The success of any project depends on the effectiveness of its managers, which is essentially dependent on the skills, level of knowledge, attitude, ability, and finally management competencies [2]. It should be acknowledged that the management and development of competencies are critical tools for increasing competition in organizations. Since the IGEDC has accountable and experienced managers, it is interested in creating more competence and empowerment. In this regard, one of the famous approaches is the Project Manager Competence Development (PMCD) model. A PMCD is a platform to handle competencies and usually has a range of competencies in the form of domains, units, and competence components. There are several definitions for the term competence. An accepted definition has been suggested by project management standards [3-6]. They have defined competence as knowledge, personal attitude, and the ability or relevant experience that allows performing one or more activities to realize an expected level of performance. The managerial competencies are like the iceberg, much of it underwater, and a small part of it, such as skill and knowledge, is located at the peak of it and is out of the water. The elements that include competencies are less visible, but they tend to control and direct the apparent behavior. One of the major problems faced by scholars is the classification of competencies. Researchers have considered different categories for competence, e.g., in Boyatzis' framework [7] three competence categories are individual, organizational, and occupational. According to Crawford [8], there may be three categories: input (the knowledge and skills that a

person brings to the project with himself), personal (the main characteristics of the person who makes him capable of performing work), and output (a verifiable function that can be displayed at work). In the Project Manager Competency Development Framework (PMDC), suggested by [3], competence may fall into one of the categories personal, technical, knowledge, performance, and contextual. In the IPMA Competence Baseline (ICB) [4], the classes are people, technical, practical, and perspective. Cha and Maytorena-Sanchez [9] investigated the relative importance of project management competencies across the different stages of a software project life cycle, and consolidated competencies into four competence dimensions cognitive, functional, social, and meta-competence. As the last instance, Do Vale et al. [10] categorized competencies as behavioral, technical or specific, management, and contextual. For a fairly complete review of the competence research, see [10] and [11]. Davoodi et al. [12] designed a PMCD for gas refineries in the South Pars Gas Complex (SPGC). They used a survey method and in-depth, semi-structured, and purposeful interviews with 15 senior managers of the gas complex to collect the data. Personnel Selection Problem (PSP) is directly relevant to competency models. From this area of research, Ozgormus et al. [13] proposed a systematic approach for the PSP of a textile company in Turkey by considering various performance requirements and criteria. They employed Fuzzy Decision Making Trial and Evaluation Laboratory (DEMATEL), Fuzzy Quality Function Deployment (QFD), and Fuzzy Grey Relational Analysis (GRA) methods. Moradi et al. [14] identified competencies that project managers of collaborative construction projects require to possess to succeed. The survey method was utilized, and a self-evaluation questionnaire was sent to project managers. Wang et al. [15] employed an improved Multi-Attribute Decision Making (MADM) method to construct the competency model of international engineering project managers. The model was mainly concentrated on the local level rather than the international level and discussed the competency of general project managers rather than a specific industry of engineering.

By comparing the competence of individuals with the competencies required for a job, organizations will easily be able to measure the level of competence of individuals. Thus, the purpose of developing a competence model in each organization is to provide a model for integrating the performance of the human resources system so that it leads to effective performance and organizational success. In line with this idea, the current paper aims to customize a PMCD for the IGEDC. The organization of the paper is as follows: In section 2, the paper describes the elements of the proposed PMCD. The next section discusses the application of the proposed model in a real-life situation. Finally, section 4 explains the concluding remarks of the paper.

2. Building the Model

The components of the proposed model were ascertained with the participation of people who have sufficient knowledge/experience in the projects at the IGEDC. In this way, 15 experts including academic members, familiar with the PMCD, project managers, and people involved in the implementation of projects at the IGEDC were selected through non-probability and purposeful sampling. Let's call them Expert Panel Member (EPM) from this point on, and define $E = 15$ ($k = 1.2. \ldots . E$). Appendix A consists of information about the EPMs (Table A1).

It should be noted that, in the entire text we use the word "owner" who is the superior decision maker about project manager appointment/change/train. Hence, this word could be truly interpreted as program manager, because a program manager oversees project managers and coordinate between them.

2.1 Phase I: Recognizing the Competencies

Stage 1: Firstly, by reviewing the relevant literature and studying the respective standards, the competence models were reviewed to create and compile an initial list of the project managers' competencies. Some of the studied references were [1], [3-8], [11], and [16-25]. In this stage, 34 competencies were identified.

Stage 2: In this stage, a questionnaire was needed to establish. For each competence, the characteristic question "Is this competence useful for a PMCD tailored for the IGEDC?" was added to the questionnaire.

Stage 3: To evaluate content validity quantitatively, firstly, the Content Validity Ratio (CVR) was used. The questionnaire was distributed among the EPMs and their views on the degree of agreement with the components of the questionnaire were obtained the errors in the structure were identified and the necessary adjustments were made to satisfy content validity and apparent validity. The EPMs were required to choose between necessary or unnecessary options for each question [26]. Then, the CVR was calculated as Eq. (1) for each question. In this equation, e is the number of EPMs (out of E = 15) who have found the question to be necessary.

$$\mathrm{CVR} = \left(\mathrm{e} - \left(\frac{\mathrm{E}}{2}\right)\right)/\left(\frac{\mathrm{E}}{2}\right) = (\mathrm{e} - 7.5)/7.5. \quad (1)$$

CVR for each question is a number between +1 and -1, so any positive value indicates that more than half of the EPMs have considered the question necessary. When CVR is zero, half of the EPMs find the question necessary. Questions that have a CVR less than a minimum value should be removed before running the test. Lawshe suggested that appropriate values of CVR should be higher than statistical odds levels. He presented Table 1 indicating minimum values of CVR based on the significance level of 0.5. For the current study, 14 competencies (out of 34) were omitted, because their CVR was less than 0.49.

Table 1. Minimum values of CVR.

E	<8	8	9	10	11	12	13	14	15	20	25	30
Min. value	0.99	0.75	0.78	0.62	0.59	0.56	0.54	0.51	0.49	0.42	0.37	0.33

Stage 4: To evaluate content validity, secondly, the Content Validity Index (CVI) was employed. The CVI is calculated as Eq. (2) for all the questions that remained in the list, i.e., 30 competencies (= 34 - 10). Therefore, the questionnaire is approved as the CVI value is 0.96 or more. For the current study, a CVI of 0.975 was obtained.

$$\mathrm{CVI} = \sum \mathrm{CVR}/\mathrm{The\ number\ of\ questions}. \quad (2)$$

Stage 5: In this stage, the EPMs had to rate the competencies, to finally refine them. To this, the Likert scale is used, and the score range is from 1 to 5 (very low useful, low useful, useful, high useful, very high useful). The responses are gathered on the platform of the Delphi method. This method involves a group of EPMs who anonymously respond to questions and subsequently receive feedback in the form of statistical representations of group response, followed by a repeat procedure. The steps of the Delphi are [27]: (1) Identifying competencies using a comprehensive review of the theoretical foundations of the research, (2) Gathering the opinions of the EPMs. In this stage, after identifying the competencies, a decision-making team of the EPMs on the main topic of the research and screening is sent, in which Likert-based linguistic variables for the expression of the importance of each competence are used, and (3) Competence confirmation and screening. This is done by comparing the value of each competence acquired with the threshold value. The threshold value of 3 is assumed, if the average score for each competence is less than 3, the competence is removed. For the current study, 4 competencies (out of 30) were omitted, because their average score was less than 3.

Stage 6: To evaluate the reliability of the answers, the Cronbach's alpha method was used. Cronbach's alpha was calculated as 0.709 in round 1 and 0.741 in round 2 of the Delphi. Both the values were above threshold 0.7, and the reliability of the answers was proved.

Stage 7: This stage was to classify the final list of the 16 competencies. To perform classification, the affinity diagram method was used, including the following steps: (1) Record each competence on

cards, (2) Look for competencies that seem to be related, and group them, and (3) Create a header for each group. For the current study, two categories were identified and named: behavioral and technical. Table 2 shows the final list of the competencies.

Table 2. Competencies for the proposed PMCD.

Symbol	Category	Competence
C01	Behavioral	Analytical & logical thinking
C02	Behavioral	Behavioral Health
C03	Behavioral	Compatibility & adaptability
C04	Behavioral	Energetic & active
C05	Behavioral	Initiative
C06	Behavioral	Interpersonal communication
C07	Behavioral	Judgment & decision making
C08	Behavioral	Leadership
C09	Behavioral	National perspective/sweat
C10	Behavioral	Negotiating & influencing others
C11	Technical	Ability to work with computers
C12	Technical	Engineering insights
C13	Technical	Engineering judgment
C14	Technical	Familiar with the gas industry
C15	Technical	Mastery of English
C16	Technical	Project management knowledge

2.2 Phase II: Determining the Application Situations

Many organizations use competence models in selection, promotion, education, uplift, performance management, and in planning success & career paths. In the proposed PMCD, three applications for the IGEDC are considered:

- Selection: Selection of the best project manager among a set of candidates.
- Enhancement: Diagnosing weak competencies of a person, to help enhance his/her abilities. This person is reckoned to be a project manager in the future.
- Pathology: In a finished project with undesirable outcomes, finding out its project manager's deficiencies in the competencies. This application is like an enhancement, but the analyst's report is different.

Accordingly, in this phase, the owner determines one of the above applications. The type of the application may have an impact on the next phases.

2.3 Phase III: Weighting the competencies

For a real-life situation from the IGEDC, the competencies need to be weighted. The weights are denoted by w_j $(j = 1.2. \dots . n)$. The competencies are weighted using a well-established method called Best Worst Method (BWM) [28] as one of the recently developed Multiple Criteria Decision Making (MCDM) tools. The BWM uses a unique structure and needs less comparison data, due to which there are fewer issues with the inconsistency that are experienced by pairwise comparison methods. A nonlinear min-max model is then built to identify the weights such that the maximum absolute

difference between the weight ratios and their corresponding comparisons is minimized. Supposing there are n competences, the BWM steps are as follows:

1 - Determine the best (e.g. most desirable, most important) and the worst (e.g. least desirable, least important) competencies. We suggest W_b is the weight of the best competence, and W_w is the weight of the worst competence.

2 - Determine the preference of the best competence over all the other competencies, using numbers between 1 and 9. The resulting numbers would be $a_{b1}. a_{b2} . a_{b3}. \ldots . a_{bn}$.

Determine the preference of all the criteria over the worst criterion, using numbers between 1 and 9. The resulting numbers would be $a_{1w}. a_{2w} . a_{3w}. \ldots . a_{nw}$.

3 - Determine the optimal weights of the competencies, using the following model (3) - (7).

$$\text{Min } \xi. \tag{3}$$

$$\left|W_b - W_j * a_{bj}\right| \leq \xi. \;\; j = 1.2. \ldots . n. \tag{4}$$

$$\left|W_j - W_w * a_{jw}\right| \leq \xi. \;\; j = 1.2. \ldots . n. \tag{5}$$

$$\sum_{j=1}^{n} w_j = 1 . \tag{6}$$

$$w_j \geq 0. \qquad j = 1.2. \ldots . n. \tag{7}$$

4 – Check the Consistency Ratio (CR). Calculate the CR using Eq. (8), where the Consistency Index (CI) is determined by Table 3. CR ranges between 0 and 1. The higher the CI shows the less consistency. A CR value less than 0.1 may be tolerated.

Table 3. CI values

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CI	0	0.44	1	1.63	2.3	3	3.73	4.47	5.23

$$\text{CR} = \xi/\text{CI}. \tag{8}$$

In the proposed model, the above procedure is performed by each EPM individually. After that, using the individual BWM weights, the product formula is employed to aggregate the weights as Eq. (9). In this equation the weights are normalized simultaneously.

$$\text{CR} = \prod_{k=1}^{E} w_j^k \,/\, \sum_{r=1}^{n} \prod_{k=1}^{E} w_r^k. \tag{9}$$

The output of this phase is a list of the competencies ranked according to the weights, from the most important to the least important. Let's assume that w_1 is the first-ranked competence, w_2 is the second-ranked competence, …, and w_n is the last-ranked competence.

2.4 Phase IV: Screening the competencies

Whether all the competencies have to be taken into account, for the next analyses? The answer is no [29-31]. Let us discuss the reason. We know that there are two extreme vectors for the competence weights: at one extreme (1, 0, 0… 0), and the other extreme (1/n, 1/n… 1/n). In the former 100% of the total weight is dedicated to the first-priority competence, while in the latter the weights are uniformly distributed through all the competencies. Thus, if the analyst has a weight vector like the former, he/she needs to just focus on the first competence! And if he/she deals with a weight

vector like the latter, considering all the competencies are required. All things considered, the proposed PMCD recommends:

"Choose only m number of the competences from the top section of the ranked list of the competences, and disregard the others. The sum of the weights of these m competencies has to be more than or equal to 0.95. This number is a default value for a threshold denoted by θ. The lower θ indicates the more tendency of the owner to be a risk taker."

According to the above recommendation, we first check the first-priority competence, if $w_1 \geq \theta$, the other competencies are removed from our analysis, otherwise, we check the first & second-priority competencies, if $w_1 + w_2 \geq \theta$, the other competences are omitted, and so on. Finally, m competencies remain on the list.

2.5 Phase V: Rating the competencies

For a real-life situation from the IGEDC, its owner has to rate the m competencies. The proposed model suggests one of the following modes to rate the competencies:

- Quantitative mode: The competencies are rated using a 1-10 scale, such that 1 shows the worst-case situation, and 10 indicates the best-case situation.
- Qualitative mode: The owner can choose one of the five levels very low, low, medium, high, or very high. Thus, in this mode, the owner does not need to give precise rates. After that, default rates (middle values) are assigned to the levels, i.e., 1.5 to very low, 3.5 to low, 5.5 to medium, 7.5 to high, and 9.5 to very high.

The rates are denoted by r_j $(j = 1.2. \ldots . m)$.

2.6 Phase VI: Decision Making

The recommended PMCD decision-making rule is:

"Firstly, the rates of the $p = \lceil 20\% * m \rceil$ The number of competencies from the top section of the list has to be more than or equal to 8. This number (=8) is a default value of a threshold denoted by α. Moreover, 20% is a coefficient based on the Pareto principle and $\lceil x \rceil$ denotes the ceiling function that maps x to the least integer greater than or equal to x. Secondly, the weighted sum of the total rates has to be more than or equal to 6. This number (=6) is a default value of a threshold denoted by β."

Let us define an index denoted by I_1 as Eq. (10). This index is an integer number that ranges from 0 to p. $I_1 = p$ means all the first p competencies have a rate more than or equal to α. $I_1 = 0$ stands for this situation where all the first p most important competencies have a rate less than α, and this is a critical situation.

$$I_1 = \sum_{j=1}^{p} 1 \text{ if } r_j \geq \alpha. \tag{10}$$

The weighted sum of the total rates is shown by I_2, and is calculated by Eq. (11).

$$I_2 = \sum_{j=1}^{n} w_j \times r_j. \tag{11}$$

As we see, there are two screening filters in the above rules with different priorities. In the first-priority filter, the first p competencies roughly play a veto role over the other competencies. After passing this veto rule, the second-priority filter is applied. This filter considers the weighted sum of the total rates, i.e., a compensatory function. It should be noted that the values of the thresholds α and β are defaults, thus the owner may change them depending on their attitudes. The higher the thresholds, the higher the difficulty in the decision-making mechanism.

Regarding the three applications of the PMCD:

- Selection: Firstly, candidates who have $I_1 = p$ are selected to be checked by the second filter. Later, among the selected persons, the owner makes the decision based on I_2.

Notably, when $I_1 < p$ For all candidates, reasonably the owner either rejects all of the candidates or adjusts the threshold α at lower levels.

- Enhancement: Firstly, if $I_1 < p$, the primary job of the owner is to make plans to enhance the competencies which are rates less than α (among p competencies). Moreover, if $I_2 < \beta$, the secondary actions of the owner would be to make plans for the sake of enhancement of all the competencies simultaneously to reach the β threshold.
- Pathology: This application is like the enhancement, but the analyst's report is different. Firstly, if $I_1 < p$ then the analyst can conclude that a major reason for unwelcome project yields is drawbacks of the project manager's abilities in the first p competencies, i.e., the competences by rates less than α. Further, a minor reason for the project management problems may be due to drawbacks of the other competencies, if $I_2 < \beta$.

2.7 Course of Action

For a given case of the PMCD, perform the following tasks respectively:

a) Determine the application of the proposed model, among selection, enhancement, or pathology, discussed in section 2.2.
b) Carry out extensive research on candidates/project managers. Get as wide as possible recognition about the candidate/project manager.
c) Weight the n (=16) competencies using the BWM discussed in section 2.3.
d) Adjust the threshold θ, and screen the n (=16) competencies using the instruction discussed in section 2.4.
e) Choose one of the quantitative or qualitative modes to rate the m competencies, discussed in section 2.5, and rate each one of the m competencies based on the chosen mode.

Adjust the thresholds α and β, and follow the decision-making rule discussed in section 2.6.

3. Study Case

For the study case, an implemented gas transmission pipeline project was taken from the IGEDC. Pathology was selected as the major application of the PMCD for this study case. In addition to the existing information, the owner gathered complementary information about the performance of the project manager.

The individual BWM weights regarding 15 EPMs are represented in Appendix B (Table B1). Notably, for all the EPMs, the objective function of the BWM mathematical programming model was equal to a very low value, often around 0.005. Hence, we concluded that the CR value for all the cases would be close to zero, i.e., surely tolerated. After aggregation of the individual weights, the final weights for the 16 competencies were obtained. Table 4 presents the sorted list of the competencies, according to the weights. Given the table, the most important competence is leadership and this indicates the high importance of leadership in the performance of project managers. According to Alharbi [32], in the landscape of progressive organizations, active leadership management comes to be the major column of success. Subsequently, project management knowledge, judgment & decision-making have the next highest weight respectively, and the least importance is related to national perspective/sweat.

Table 4. Competences in order of weights

Symbol	Competence	Weight
C08	Leadership	0.870955117441
C16	Project management knowledge	0.073986226675
C07	Judgment and decision-making	0.047276982357
C13	Engineering judgment	0.004861737888
C12	Engineering insights	0.001379157076
C06	Interpersonal communication	0.000897257194
C02	Behavioural health	0.000460867926
C09	Negotiating and influencing others	0.000079128142
C05	Initiative	0.000060206979
C14	Familiar with oil industry rules	0.000029561933
C01	Analytical and logical thinking	0.000013158145
C04	Energetic and active	0.000000556991
C03	Compatibility and adaptability	0.000000033201
C11	Ability to work with computers	0.000000007730
C15	Mastery of English	0.000000000297
C09	National perspective/sweat	0.000000000027

By adjusting $\theta = 0.95$:
$w_1 = 0.8710 < \theta$
$w_1 + w_2 = 0.8710 + 0.0739 = 0.9449 < \theta$
$w_1 + w_2 + w_3 = 0.8710 + 0.0739 + 0.0473 = 0.9922 > \theta$
Thus m = 3, which caused 13 competencies out of 16 to be eliminated. Consequently, three competencies (leadership, project management knowledge, and judgment & decision-making) have remained on the list. To rate the competencies, the quantitative mode was chosen. To help the owner, three rating tables were provided for three competencies as follows.
Table 5 includes the rating guidelines for leadership competence. This table is built based on Dulewicz and Higgs [33] who expressed 15 dimensions for leadership (shown in the top row of Table 5).

Table 5. Leadership rating table.

Fifteen leadership dimensions: **Critical analysis & judgment, vision & imagination, strategic perspective, engaging communication, managing resources, empowering, developing, achieving, self-awareness, emotional residence, motivation, interpersonal sensitivity, influencing, intuitiveness, and conscientiousness**			
C08	Guideline	Rate	Middle
Very low	The person has acceptable abilities in less than 4 leadership dimensions.	1-2	1.5
Low	The person has acceptable abilities in 4 to 6 leadership dimensions out of 15.	3-4	3.5
Medium	The person has acceptable abilities in 7 to 9 leadership dimensions out of 15.	5-6	5.5
High	The person has acceptable abilities in 10 to 12 leadership dimensions out of 15.	7-8	7.5
Very high	The person has acceptable abilities in more than 12 leadership dimensions.	9-10	9.5

Table 6 depicts a rating table for project management knowledge competence. This table is established based on [34]. In this famous standard, project management knowledge is divided into 10 areas of management (called Project Management Body of Knowledge-PMBOK). These areas are exhibited in the first row of Table 6.

Table 6. Project management knowledge rating table.

Ten PMBOK areas: **Integration, scope, time, cost, quality, human resources, communication, risk, procurement, and stakeholder.**			
C16	Guideline	Rate	Middle
Very low	The person has acceptable knowledge in less than 3 PMBOK areas.	1-2	1.5
Low	The person has acceptable knowledge in 3 or 4 PMBOK areas out of 10.	3-4	3.5
Medium	The person has acceptable knowledge in 5 or 6 PMBOK areas out of 10.	5-6	5.5
High	The person has acceptable knowledge in 7 or 8 PMBOK areas out of 10.	7-8	7.5
Very high	The person has acceptable knowledge in more than 8 PMBOK areas.	9-10	9.5

The judgment & decision-making rating table is presented in Table 7. In this table, three major dimensions of judgment & decision-making are taken into account: past experiences, cognitive biases, and escalation of commitment [35-36]. According to Juliusson et al. [35], past failure or success in decisions by the person influences the decisions people make in the future. Cognitive biases are thinking behaviors based on observations and generalizations, which may lead to errors in memory, improper judgments, and faulty logic [36]. There are a variety of cognitive biases. For instance, in hindsight bias, the person tends to readily describe an event as inevitable, once it has happened. In another instance, a person may have a propensity to remove information perceived as risky; this is called omission bias. Regarding escalation of commitment, Juliusson et al. [35] indicated that a person may make decisions based on an irrational escalation of commitment, i.e., he/she consumes a lot of resources such as time and money for a decision to which he/she feels committed.

To use Table 7, the sub-rates concerning past experiences, cognitive bias, and escalation of commitment were determined, after that the mean value was used as the rate of judgment & decision-making.

Table 7. Judgment & decision-making rating table.

C07	**Guideline**			**Rate**	**Middle**
	Past successful experiences in decision-making	Observed cognitive biases in judgments	Influenced by escalation of commitment		
Very low	Very little experiences	A lot of cases	Very profound	1-2	1.5
Low	Little experiences	Many cases	Profound	3-4	3.5
Medium	So-so	Sometimes	Intermediate	5-6	5.5
High	Many experiences	A few cases	Shallow	7-8	7.5
Very high	So many experiences	No cases	Very shallow	9-10	9.5

The owner benefits from the above tables and determines the level of leadership on $r_1 = 6$, and the level of project management knowledge as $r_2 = 5$. Regarding judgment & decision-making, the owner believed that the project manager had a high level of past experiences with acceptable performance and no considerable cognitive biases; therefore, a rate of 9 is determined for these two dimensions. Further, the owner preferred a sub-rate of 5 for influenced by an escalation of commitment. Finally, an average of 9, 9, and 5 was set for the rate of judgment & decision-making, i.e., $r_3 = 7$.

In decision-making phase, the PMCD default values for the thresholds were confirmed by the owner, i.e., $\alpha = 8$ and $\beta = 6$. Calculations resulted in:

$p = \lceil 20\% * 3 \rceil = 1,$

$I_1 = 0$ (Because $r_1 < \alpha$)

$I_2 = 0.8710 \times 6 + 0.0739 \times 5 + 0.0473 \times 7 = 5.9224$

Accordingly, because $I_1 = 0$ The owner concluded that the leadership competence of his/her project manager had been the fundamental issue, and the other project manager's competencies have had little effect on the project performance.

4. Concluding Remarks

To maintain the IGEDC's professional competence, the paper presented a study concentrated on the establishment of a tailored PMCD for this company. The paper first identified the areas of competencies required for a project manager in the IGEDC and assigned numerical weights to the competencies. To these, several methods were used, such as the Delphi, Affinity diagram, and BWM.

The proposed PMCD was designed in such a way that its users can benefit from many flexible aspects: (1) flexibility in applications, i.e., selection, enhancement, and pathology, (2) flexibility in screening the competencies, using adjustable parameters, (3) flexibility in rating the competences, i.e., quantitative and qualitative, and (4) flexibility in decision making, using the rules built on adjustable thresholds. Furthermore, the proposed PMCD suggested that users employ rating tables to help measure the competencies.

The results revealed that leadership, project management knowledge, and judgment & decision-making are the most important competencies required for the IGEDC project managers. As a major result, leadership is a unique competence by more than 85% of the total weight.

The following empirical recommendations are suggested for future research in line with the current study: (1) designing a comprehensive system for enhancing the IGEDC project managers' competencies based on the proposed PMCD, (2) integrating the PMCD to the other systems in the IGEDC, e.g., project management system and human resource management, and (3) developing similar customized models for the other companies of the petroleum industry, e.g., National Iranian Oil Company (NIOC).

Declarations

Ethics Approval and Consent to Participate

The results/data/figures in this manuscript have not been published elsewhere, nor are they under consideration by another publisher. All the material is owned by the authors, and/or no permissions are required.

Consent for Publication

This article does not contain any studies with human participants or animals performed by any of the authors.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Competing Interests

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Author Contribution

All authors contributed equally to this research.

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Appendix A

Table A1. The EPM's information

EPM	Age range	Gender	Degree
P1	36-40	female	**M.Sc.**
P2	36-40	female	**M.Sc.**
P3	36-40	female	**Ph.D.**
P4	31-35	female	**M.Sc.**
P5	31-35	female	**M.Sc.**
P6	36-40	female	**M.Sc.**
P7	36-40	female	**Ph.D.**
P8	31-35	female	**M.Sc.**
P9	36-40	male	**M.Sc.**
P10	36-40	male	**M.Sc.**
P11	40-50	male	**Ph.D.**
P12	40-50	male	**Ph.D.**
P13	50-60	male	**Ph.D.**
P14	31-35	male	**M.Sc.**
P15	36-40	male	**M.Sc.**

Appendix B

Table B1. The individual weights by the EPMs.

Symbol	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C01	0.1100	0.0470	0.0780	0.0900	0.0520	0.0300	0.0320	0.0380	0.0540	0.0330	0.0430	0.0360	0.0350	0.0500	0.1000
C02	0.0320	0.0340	0.1200	0.0600	0.0600	0.0900	0.0800	0.0940	0.0540	0.0820	0.0860	0.0600	0.0440	0.0650	0.0560
C03	0.0400	0.0340	0.0520	0.0360	0.0520	0.0130	0.0270	0.0310	0.0320	0.0330	0.0430	0.0300	0.0350	0.0330	0.0370
C04	0.0400	0.0300	0.0480	0.0590	0.0770	0.0290	0.0360	0.0280	0.0400	0.0410	0.0320	0.0440	0.0540	0.0250	0.0590
C05	0.0400	0.0410	0.1300	0.0900	0.0730	0.0450	0.0320	0.0470	0.0540	0.0540	0.1400	0.0450	0.0590	0.0400	0.0370
C06	0.0450	0.1100	0.0780	0.0900	0.0520	0.0900	0.1100	0.0630	0.0800	0.1000	0.0570	0.0450	0.0350	0.0500	0.0560
C07	0.0560	0.1200	0.0780	0.0900	0.0400	0.1300	0.0800	0.0940	0.1100	0.0540	0.0860	0.0900	0.0880	0.1000	0.1600
C08	0.0450	0.1600	0.0780	0.0900	0.0450	0.1700	0.1500	0.1500	0.1500	0.1500	0.0860	0.0900	0.0880	0.1500	0.1100
C09	0.0320	0.0260	0.0100	0.0250	0.0730	0.0220	0.0180	0.0270	0.0230	0.0200	0.0110	0.0220	0.0100	0.0250	0.0150
C10	0.0450	0.0800	0.0780	0.0900	0.0520	0.0600	0.0400	0.0470	0.0800	0.0400	0.0570	0.0600	0.0440	0.0500	0.0560
C11	0.0320	0.0470	0.0260	0.0360	0.0420	0.0360	0.0400	0.0130	0.0320	0.0120	0.0290	0.0160	0.0440	0.0500	0.0450
C12	0.1900	0.0150	0.0520	0.0360	0.0450	0.0450	0.0800	0.0630	0.0800	0.0820	0.0860	0.1800	0.1400	0.1000	0.0450
C13	0.1600	0.0470	0.0400	0.0360	0.0450	0.0600	0.0800	0.0940	0.0800	0.0820	0.0860	0.1100	0.1200	0.1000	0.0750
C14	0.0450	0.0820	0.0400	0.0300	0.1200	0.0600	0.0530	0.0480	0.0400	0.0540	0.0430	0.0600	0.0590	0.0500	0.0560
C15	0.0130	0.0470	0.0400	0.0120	0.1200	0.0300	0.0120	0.0230	0.0110	0.0330	0.0290	0.0220	0.0250	0.0120	0.0370
C16	0.0750	0.0800	0.0520	0.1300	0.0520	0.0900	0.1300	0.1400	0.0800	0.1300	0.0860	0.0900	0.1200	0.1000	0.0560

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