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# Project manager selection based on project manager competency model: PCA–MCDM Approach

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A B S T R A C T

Personnel selection is one of the most important problems that organizations have to deal with. Competent personnel is one of the key factors for the success of organizations. Project manager selection due to special requirements is significantly important. A project manager must have the ability of managing costs, time and resources through the optimistic way. Furthermore he/she has to own general management skills and benefit from adequate information about the project context. Project managers in petroleum industry carry very important duties than other project managers. In this research, we try to develop a model in order to select a project manager for petroleum industry. The proposed model is based on multi criteria decision making and a statistical method named principle component analysis (PCA). The methodology considers all of the important criteria and benefit from an experienced expert panel in order to extract the weights of the criteria. Also a numerical example demonstrates the function of the model and is verified by VIKOR method.

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## 1. Introduction

One of the most important decisions in project management is to choose project managers. Project manager choices may cause failure of a routine project or conversely may cause an unbelievable success in projects with many unforeseen obstacles and problems. As organizations increasingly focus on human assets as a competitive advantage, they expect higher levels of performance from their employees. Schoonover et al. (2001) anticipate the use of competencies as a strategic intervention to continue, and even to accelerate firms' success. Competencies are behaviors that encompass the knowledge, skills, and attributes required for successful performance. In addition to intelligence and aptitude, the underlying characteristics of a person, such as traits, habits, motives, social roles, and self-image, as well as the environment around them, enable a person to deliver superior performance in a given job, role, or situation.

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The project manager has specific accountability for achieving the entire defined project objectives within the time and resources allocated. The project manager performs the day-to-day management of the project. One or more assistant project managers with the same responsibilities over specific portions of the project may support the overall project manager, without diluting his or her responsibility. Project managers must demonstrate knowledge, skills and experience commensurate with the size, complexity and risk of the project. Since different levels of competency are required for various levels of project management and project size, the project manager role is divided into three proficiency levels. Depending on the size, complexity and risk of the project, more than one level of project manager may share responsibility for managing the project. The selection of project manager considers the concepts of the project in relation that roles characteristic. This concept contains the typical role of the project manager and links it to the skills that are required by an effective project manager. Interviewing related candidates is one of the techniques concerning human resource selection (Robertson & Smith, 2001). There are many studies fulfilled in the literature, which are based on interviews, work samples, tests, assessment centers, job knowledge and personality tests in human resource management (Chien & Chen, 2008; Dodangeh et al., 2014), and in the special case of project manager selection, also we could consider project management (PM) knowledge, social awareness, leadership abilities and stakeholder management as important criteria. But multi criteria decision making (MCDM) techniques were used by only few of them (Dursun & Karsak, 2010). Traditional personnel selection method used an experimental and statistical techniques approach (Chien & Chen, 2008). Searching for MCDM, fuzzy logic, and human resource, selection separately has a few results in research databases, but searching for the keywords together results in more researches. In this paper, we consider a number of criteria and related sub-criteria in order to match of project managers of petroleum and gas projects, and because of the potential importance of this industry in countries with huge resources of fossil fuels, these managers should have the essential competencies. The proposed criteria and sub-criteria were identified based on associated references and literature of project management involved gas and petroleum project management.

The most important competencies for a project manager are different in fields but these fields are common in many categories, these categories could contain even a manager's social behaviors or decision making in uncertainty situation. But in practice the essential feature that a project manager should own it genetically is to understand the actual weight of activities and make appropriate decision when several parameters combined each other simultaneously, regarded to the weights and impotency of each activates in the shortest time. Actually modeling and solving it with computer is not only impossible and there is not enough time and resource for everybody.

In this paper we try to consider a new competency body for project manager that is containing core competencies that an efficient project manager should own it. It has been years that many scholars have used MCDM approaches such as AHP, ANP, VIKOR, TOPSIS and etc. for personnel selection problems and their solutions were satisfactory. In this paper we propose a multi criteria decision making algorithm, which has been widely accepted multi-attribute decision making technique and is based on network analysis. The outputs of principal component analysis (PCA) would be ANP's Inputs. We proposed principal component analysis (PCA) to reduce the size of the problem. PCA was invented in 1901 by Karl Pearson. As an analogue of the principal axes theorem in mechanics; it was later independently developed and named by Harold Hotelling in the 1930s. The method is mostly used as a tool in exploratory data analysis and for making predictive models. PCA can be done by eigenvalue decomposition of a data covariance (or correlation) matrix or singular value decomposition of a data matrix, usually after mean centering (and normalizing or using Z-scores) the data matrix for each attribute (Abdi & Williams, 2010). The results of a PCA are usually discussed in terms of component scores, sometimes called factor scores (the transformed variable values corresponding to a particular data point), and loadings (the weight by which each standardized original variable should be multiplied to get the component score) (Shaw, 2003).

## 2. Literature Review

Schoonover et al. (2001) conducted a study to determine how organizations are actually using competency data and to provide insights into real-life practices that lead to success. A competency model is defined as “a descriptive tool that identifies the knowledge, skills, abilities, and behaviors needed to perform effectively in an organization” (Chung-Herrera et al., 2013). Jabar et al. (2013) made an investigation on initial information related to the competency of construction managers in the context of Industrialized Building System (IBS) construction project in Malaysia. Peerasit and Milosevic (2008) proposed interdependency management, multitasking, simultaneous team management, and management of inter project process as list of competencies that multiple project managers should possess. Hadad et al. (2013) proposed a decision making support system (DMSS) module for selecting project manager and demonstrated its implementation. The selection method was based on their past performance in the relative projects. In Zhang et al. (2013), a well-established competency model has been adopted from human resource management theories framework to examine the social competencies of construction presented. They identified and explained patterns of similarities and differences among applied career models for project managers, and also outlined two archetype of career models applied by the firm under study, competence strategy model and talent management model (Bredin & Söderlund, 2013). Obradovic (2013) proposed a theoretical method that research project manager's emotional intelligence and their professional success. Dodangeh et al. (2014) developed a model regardless to the dependency of criteria using fuzzy linguistic variables with multi-criteria decision making in order to in personnel selection. Zavadskas et al. (2008) completed a model based on multicriteria evaluation of construction managers. They offered a multiple criteria method of complex proportional assessment of alternatives with grey relations for analysis. The MCDM has been used in selecting project managers. Chen and Cheng (2005) developed a fuzzy MCDM method for information system project manager selection. Bi and Zhang (2006) analyzed the significance of choosing an eligible project manager in their study. They used fuzzy AHP which was based on triangular fuzzy numbers in order to access quantitatively the ability and quality of each project manager. Mufti et al. (2016) made a research attempts to explore the human resource competencies of banking sector employees in Pakistan. Human resource competency survey model encompasses strategic contribution, business knowledge, personal credibility, human resource delivery and technology, incorporated in this study. Heris and Rostami (2015) proposed a fuzzy TOPSIS method in order to evaluate some well-known project management standards, but did not consider enough criteria. Xu and Lin (2016) used in their paper a hybrid PCA-DP technique to select public transit city in Xiamen city. The research of Afshari et al. (2012) aimed to develop a fuzzy MCDM model for linguistic reasoning under new fuzzy group decision making. In the literature review of the project manager selection field many papers have been published to handle the decision making problem. In these kinds of papers, operation research, artificial intelligence fields, expert systems, fuzzy linguistic variables, neural networks, and MCDM techniques have been used as methodologies. In order to describe the method transparently we divided the process of the problem into 5 different steps that each individual one of them has its own description and sub-sections.

## 3. The propsoed model

### *3.1. Model Definition*

MCDM is one of the well-known topics of decision making analysis method. MCDM is a sub-discipline of operations research that explicitly considers multiple criteria in decision making environments. Structuring complex problems well and considering multiple criteria explicitly lead to more informed and better decisions. There have been important advances in this field since the start of the modern multiple-criteria decision-making discipline in the early 1960s. The proposed model consists of three different MCDM methods; namely AHP, TOPSIS and VIKOR, and a statistical reduction process, principal component analysis or PCA has been used to reduce the computations. The proposed model is summarized as follows,

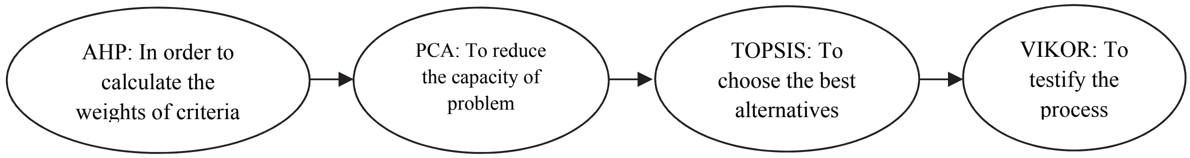


**Fig. 1.** Model Algorithm

**A.** principal component analysis (PCA)

PCA is a way of identifying patterns in the correlated data and expressing the data in such a way to highlight their similarities and differences. The main advantage of PCA is that once the patterns in data have been identified, the data can be compressed, i.e., by reducing the number of dimensions, without much loss of information. The methods involved in PCA are discussed below.

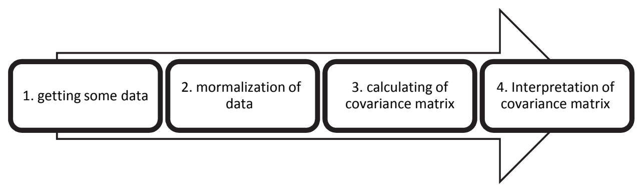


**Fig. 2.** Steps of PCA

The normalized data have then been utilized to construct a variance - covariance matrix M, which is illustrated as below:

$$\begin{bmatrix} N_{1,1} & \cdots & N_{1,p} \\ \vdots & \ddots & \vdots \\ N_{q,1} & \cdots & N_{q,p} \end{bmatrix} \tag{1}$$

$$N_{k,j} = \frac{Cov\left(Y_{ij}^{*}, Y_{ij}^{*}\right)}{\sqrt{Var\left(Y_{ik}^{*}\right) Var\left(Y_{ij}^{*}\right)}} \tag{2}$$

where $p$ stands for the number of quality characteristics, and ρ stands for number of experimental runs. Then, eigenvectors and eigenvalues of matrix M can be computed, which are denoted by $\overline{V}_i$ and $\lambda_j$ , respectively. In PCA, the eigenvector $\overline{V}_i$ represents the weighting factor of $j$ number of quality characteristics of the $j^{th}$ principal component. For example, if $Q_j$ represents the $j^{th}$ quality characteristic, the $j^{th}$ principal component $\psi_j$ can be treated as quality indicator with required quality characteristic.

$$\psi = V_{1j} Q_1 + \ldots + V_{jj} Q_j = \overline{V}_j \overline{Q} \tag{3}$$

It is to be noted that every principal component $\psi_j$ represents a certain degree of explanation of the variation of quality characteristics, namely, the accountability proportion (AP). When different principal components are accumulated, it contributes the accountability proportion of quality characteristics. This is denoted as cumulative accountability proportion (CAP). In the present work, the composite principal component $\psi$ has been introduced as the combination of principal components with their individual eigenvalues. This composite principal component $\psi$ serves as the representative of multi quality responses, called multi composite quality indicator. If a quality characteristic $Q_j$ strongly dominates in the $j^{th}$ principal component, this PCA becomes the major indicator of such a quality characteristic. Note that one quality indicator may often represent all the multi quality characteristics.

*TOPSIS method*

TOPSIS method is one of the best grading methods in MCDM and it is based on the concept that the chosen alternative should have the shortest geometric distance from the positive ideal solution and the longest geometric distance from the negative ideal solution. Method is presented in Chen and Hwang (1992), with reference to Hwang and Yoon (1981). The TOPSIS procedure consists of the following steps:

1- Calculated the normalized matrix; the normalized value Xij calculated by following phrase:

$$x_{ij} = \frac{f_{ij}}{\sqrt{\sum_{j=1}^{i} f_{ij}^2}} \tag{4}$$

2-Calculate the weighted normalized decision matrix. The weighted normalized value *Vij* is calculated as:

$$V_{ij} = w_i * x_{ij} \tag{5}$$

3- Determine the ideal and negative-ideal solution, $f^*$ and $f^-$.

4- Calculate the separation measures, using the n dimensional Euclidean distance. The separation of each alternative from the ideal solution is given as:

$$. S_j^* = \sqrt{\left(v_{ij} - v_i^*\right)^2} \tag{6}$$

$$S_j^- = \sqrt{\left(v_{ij} - v_i^-\right)^2} \tag{7}$$

5- Calculate the relative closeness to the ideal solution. The relative closeness of the alternative:

$$C_j^* = \frac{S_j^-}{S_j^- + S_j^*} \tag{8}$$

6- Rank the preference order.

## 4. Research Methedology

### *4.1. Algorithm*

The algorithm of project manager selection has been illustrated in the Fig. 1 and it shows a comprehensive vision of our policy in the selection policy. In this part, model, inputs, processes, outputs, are systematically outlined in the flowchart of modeling process for project manager selection. Different phases are explained as follow:

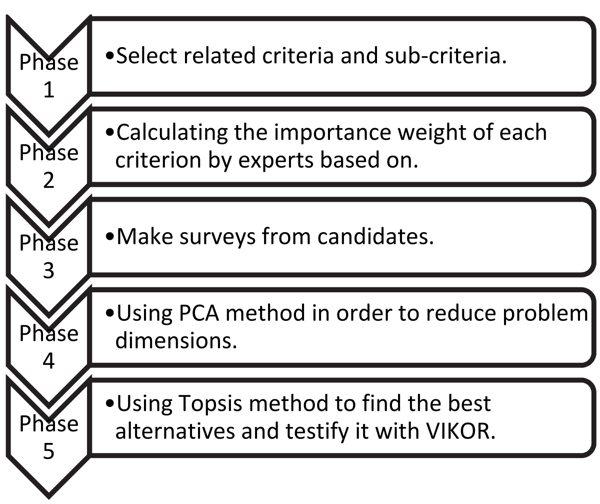


**Fig. 3**. Algorithm of project manager selection

In the first phase, we extract the criteria and sub-criteria based on expert opinions, PMBOK and related references. And members of expert panel who have significant experiences tried to introduce the selected criteria involved in project management. In the second phase, the weights of criteria will be calculated, the calculations are based on expert's opinions. In phase three, we do a survey in order to complete the competency tables that will explain them in the following sections. Phase four is associated with PCA method with SPSS software; in this part we will use PCA method to reduce the problem's diminutions. Phase five shows the final part which is the utilization of ANP method in order to rank the best alternatives.

- This document details the core competencies, or basic skills, required by a person managing Gas and petroleum project (GAPP). First, the PM must have skills in general management. Skills such as leadership, negotiation, communication, team building and other human resource management skills are necessary in any management position.
- Second, the PM must have knowledge of the generally accepted project management areas, such as project scope management using a work breakdown structure; project time management using Gantt and program evaluation and review technique (PERT) methods; and project cost management using budgeting and accounting methods.
- Third, the project manager of Petroleum and gas project should have these project management skills.

In this paper, we have divided the management of projects into the three management abilities, that a project manager should own them. Also we consider the P&G project management abilities and sharing with other management categories. The three areas illustrated in Fig. 2 complement and build on each other. For example, the PM of a PETROLEUM project must plan the scope, time and cost of his or her project using skills detailed in the Project Management section. Then the PM may have to form an effective development team to implement the plan. For this, the PM needs basic team building skills, as detailed in the General Management section. A PETROLEUM development team, however, must be formed in a very specific fashion: it must be small; it must have a combination of very specific skills; it must grow and shrink with the phases of the software project; and the appropriate IT tasks should be delegated. The skills required to do this are detailed in the Petroleum Management section.

**Table 1**
Necessity of each category

| | |
|---|---|
| General Management | To ensure proper management practices |
| Project Management | To ensure quality project process and result |
| Petroleum Project Management | To create acquire quality Petroleum project |

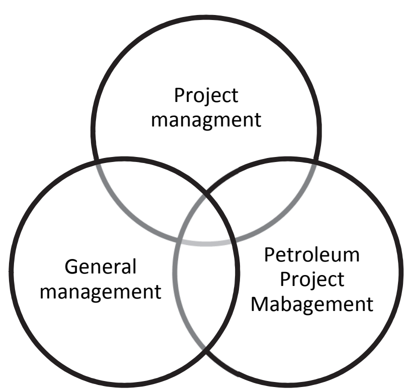


**Fig. 3**. Management sharing

### 4.2. Descrption and extracting of the criteria

**Table 2**
Criteria and sub-criteria (references 22, 23) and expert panel

| Project Manager criteria and sub-criteria | | | |
|---|---|---|---|
| 1. General Management | 1.1 | Knowledge | Judgment, Integrity, Self-confidence, Flexibility, Initiative, Perseverance, thinking skills, organizational awareness… |
| | 1.2 | Legal Skills | Owning general knowledge about legal rules and laws adjusted by government |
| | 1.3 | Communication | To shape others' understanding in ways that capture interest, inform and gain support. |
| | 1.4 | Social awareness | PM emotional behaviors could an important key reach successfulness |
| | 1.5 | Action management | To achieve expected results through the successful and timely completion of activities and delivery of Products and services. |
| | 1.6 | Financial Management | Ability to keep financial flows under control and perceive the concepts of finance |
| 2. Project Management | 2.1 | Integration | To co-ordinate the diverse components of the project by quality project planning, execution and change control to achieve required balance of time, cost and quality. |
| | 2.2 | Report | To distribute quality project information. |
| | 2.3 | Risk | To identify and control risk. |
| | 2.4 | Scope | To create quality product by including only the required work and to control scope changes. |
| | 2.5 | Human resource | To employ quality leadership to achieve quality teamwork. |
| | 2.6 | Procurement | To ensure quality service or product acquisition. |
| | 2.7 | Time | To ensure timely completion of the project |
| | 2.8 | Quality | To ensure that the product will satisfy the requirements |
| | 2.9 | Cost | To ensure that the project is completed within allotted budgets. |
| 3.project Management | 3.1 | Associated resume | The result of previous activities in the PETROLEUM project leadership, Cost, Time, scope…. |
| | 3.2 | Multiple project* management | Organizational experience, inter pendency management, multitasking, simultaneous team management, management of inter-project possess |
| | 3.3 | Technical skills | Own enough general knowledge about technical staff like reading plans, designing software and etc. |
| | 3.4 | Availability for the project | On of the most important role of a project manager is to be accessible to make decision in the project duration |

Based on the experts' panel opinions and the information gained from references, the criteria have been prepared as follow: Project management skills are organized around the nine knowledge areas described in the Project Management Body of Knowledge (PMBOK) published by the Project Management Institute. The related requirement to Petroleum project management has been extracted from experts. Descriptions of each criterion is illustrated in Table 2. Each role in project management will require a unique competency gauge, the project leader will require mostly project management skills followed by general management regarded to PETROLEUM project management abilities. Additionally, we rated each skills level on a scale of 0 to 5 as follow:

**Table 3**
An example for "knowledge" criteria

| Level | Specification |
|---|---|
| 1 | No specific knowledge or performance |
| 2 | Just Own basic knowledge |
| 3 | Full knowledge, just academic without |
| 4 | Real performance |
| 5 | Full knowledge with performance under |
| 6 | Supervision |
| 7 | Full knowledge, Performs as Supervision |
| 8 | Performs, teaches, leads, |
| 9 | Directs, … |

**Table 4**
An example for "Risk Management" criteria

| Level | Specification |
|---|---|
| 1 | Not own a specific Risk knowledge |
| 2 | Just Own general Risk management Skills |
| 3 | Own professional skills and worked |
| 4 | With PM Risk, just academic. |
| 5 | Passed Courses |
| 6 | Professional skills in PM risk with performance |
| 7 | Full knowledge, teaches, |
| 8 | Performs, appliance, leads, directs, … |
| 9 | |

## 5. AHP Method

In this section, we used AHP method in order to define the criteria's weights. The comparison between each criteria and sub-criteria has been extracted from expert panel and are shown in the following tables. The first level's comparisons have been shown in the following table and the regarded weight of each criteria has been extracted. In the second stage the comparisons between sub-criteria's of the three main criteria has been extracted and weight of each criteria is been calculated either.

**Table 5**

Comparisons in first level

| Criteria | General Management | Project Management | Petroleum Management | weight |
|---|---|---|---|---|
| General Management | 1 | - | - | 0.088 |
| Project Management | 3 | 1 | - | 0.243 |
| Petroleum Management | 7 | 3 | 1 | 0.668 |

**Table 6**

Comparisons in second level, general management

| | Knowledge | Communication | Social awareness | Action management | Legal Skills | Financial Management | weight |
|---|---|---|---|---|---|---|---|
| Knowledge | 1 | - | - | - | - | - | 0.203 |
| Communication | 1 | - | - | - | - | - | 0.146 |
| Social awareness | 1/3 | 1/3 | - | - | - | - | 0.061 |
| Action management | 1 | 3 | 3 | - | - | - | 0.242 |
| Legal Skills | 1/3 | 1/3 | 1 | 1/3 | - | - | 0.061 |
| Financial Management | 1 | 3 | 5 | 1 | 5 | 1 | 0.203 |

**Table 7**

Comparisons in second level, project management

| | Integration | Report | Risk | Scope | Human resource | Procureme nt | Time | Quality | Cost | weight |
|---|---|---|---|---|---|---|---|---|---|---|
| Integration | 1 | - | - | - | - | - | - | - | - | 0.131 |
| Report | 0.2 | 1 | - | - | - | - | - | - | - | 0.041 |
| Risk | 1 | 3 | 1 | - | - | - | - | - | - | 0.133 |
| Scope | 1 | 3 | 1 | 1 | - | - | - | - | - | 0.143 |
| Human resource | 1 | 3 | 1 | 1 | 1 | - | - | - | - | 0.133 |
| Procurement | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1 | - | - | - | 0.032 |
| Time | 1 | 5 | 1 | 1 | 1 | 7 | 1 | | - | 0.154 |
| Quality | 1 | 3 | 1/3 | 1/5 | 1/3 | 3 | 1/3 | 1 | - | 0.064 |
| Cost | 1 | 5 | 1 | 1 | 1 | 7 | 1 | 5 | 1 | 0.165 |

**Table 8**

Comparisons in second level, Petroleum project management

| | Associated resume | Multiple project management | Technical skills | Availability for the project | weight |
|---|---|---|---|---|---|
| Associated resume | 1 | - | - | - | 0.28 31 |
| Multiple project management | 1 | 1 | - | - | 0.21 73 |
| Technical skills | 1/3 | 1/3 | 1 | - | 0.08 12 |
| Availability for the project | 1 | 3 | 5 | 1 | 0.41 85 |

In the hierarchical process of criteria two of the second level of criteria have sub-criteria, so the comparison between them has been completed and the weights of each criteria is calculated in Table 9 and Table 10 as follows,

**Table 9**
Comparisons in third level, knowledge management and technical skills

| | Leadership | Decision making | Planning | Coordinating | Weight |
|---|---|---|---|---|---|
| Leadership | 1 | - | - | - | 0.243 |
| decision making | 1 | 1 | - | - | 0.306 |
| Planning | 1 | 1 | 1 | - | 0.306 |
| Coordinating | 1 | 1/3 | 1/3 | 1 | 0.143 |

**Table 10**
Comparisons in third level, knowledge management and technical skills

| | Activity design | Forecasting technique | Technical report | Technology knowledge | Weight |
|---|---|---|---|---|---|
| Activity design | 1 | - | - | - | 0.269 |
| Forecasting technique | 3 | 1 | - | - | 0.564 |
| Technical report | 1/3 | 1/5 | 1 | - | 0.091 |
| Technology knowledge | 1/5 | 1/7 | 1 | 1 | 0.0752 |

In this part, we validate our criteria in real world. First of all we have chosen a sample and then made a survey from them to extract their abilities and competencies in order to select the best candidate. We use a hybrid of PCA-TOPSIS method in order to select and rank the candidate and to examine the model by another MCDM method VIKOR. In order to confirm our research we performed a survey from 24 experienced project managers and finally 6 of them were chosen to the final selection. The criteria have been extracted from the previous part and these 6 project managers were verified by 25 criteria and the results are shown in Table 8. We consider for each single criteria an amount of certain weight that has been extracted from an expert panel. Also each criterion has a unique scale from 1 to 5 like the tables that we explained in the previous part. One of the important points in the results is that two of the project managers have not had experiences in the petroleum industry, but because of the other qualifications they participated in the survey. The candidate tables and complete weighted matrix is shown in Table 11 anf Table 12 as follows.

**Table 11**
Decision matrix

| 1.General Management | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Code | 1.1 | | | | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 |
| subs | 1.1.1 | 1.1.2 | 1.1.3 | 1.1.4 | | | | | |
| #1 | 1 | 2 | 3 | 8 | 4 | 8 | 8 | 1 | 1 |
| #2 | 1 | 3 | 6 | 8 | 6 | 3 | 5 | 1 | 5 |
| #3 | 9 | 3 | 9 | 8 | 4 | 1 | 6 | 1 | 4 |
| #4 | 7 | 4 | 7 | 9 | 4 | 1 | 4 | 3 | 6 |
| #5 | 1 | 7 | 7 | 3 | 8 | 9 | 8 | 5 | 6 |
| #6 | 5 | 6 | 8 | 8 | 1 | 4 | 8 | 2 | 4 |
| W | 0.0044 | 0.0055 | 0.0055 | 0.0026 | 0.0129 | 0.0055 | 0.0214 | 0.0055 | 0.0250 |

| 2.Project Management | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Code | 2.1 | 2.2 | 2.3 | 2.4 | 2.5 | 2.6 | 2.7 | 2.8 | 2.9 |
| #1 | 8 | 2 | 2 | 5 | 8 | 2 | 7 | 7 | 6 |
| #2 | 9 | 7 | 1 | 1 | 2 | 6 | 1 | 2 | 3 |
| #3 | 9 | 8 | 5 | 5 | 5 | 1 | 8 | 1 | 7 |
| #4 | 3 | 6 | 5 | 7 | 6 | 7 | 1 | 4 | 7 |
| #5 | 7 | 4 | 5 | 3 | 8 | 5 | 1 | 3 | 6 |
| #6 | 9 | 2 | 7 | 8 | 1 | 2 | 1 | 3 | 1 |
| W | 0.0319 | 0.0101 | 0.0325 | 0.0350 | 0.0325 | 0.0078 | 0.0376 | 0.0157 | 0.0401 |

| 3. Petroleum Management | | | | | | | |
|---|---|---|---|---|---|---|---|
| Code | 3.1 | 3.2 | 3.3 | | | | 3.4 |
| subs | | | 3.3.1 | 3.3.2 | 3.3.3 | 3.3.4 | |
| #1 | 8 | 1 | 3 | 5 | 9 | 1 | 5 |
| #2 | 4 | 7 | 3 | 5 | 1 | 5 | 4 |
| #3 | 2 | 5 | 1 | 8 | 7 | 7 | 3 |
| #4 | 4 | 4 | 8 | 8 | 3 | 5 | 7 |
| #5 | 6 | 6 | 8 | 1 | 1 | 9 | 7 |
| #6 | 1 | 4 | 3 | 2 | 7 | 1 | 1 |
| W | 0.1893 | 0.1453 | 0.0146 | 0.0307 | 0.0049 | 0.0041 | 0.2798 |

**Table 12**
Weighted matrix

| | 1.General Management | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Code | 1.1 | | | | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 |
| subs | 1.1.1 | 1.1.2 | 1.1.3 | 1.1.4 | | | | | |
| #1 | 0.0044 | 0.0110 | 0.0165 | 0.0207 | 0.0516 | 0.0437 | 0.1709 | 0.0055 | 0.0250 |
| #2 | 0.0044 | 0.0165 | 0.0330 | 0.0207 | 0.0774 | 0.0164 | 0.1068 | 0.0055 | 0.1252 |
| #3 | 0.0394 | 0.0165 | 0.0495 | 0.0207 | 0.0516 | 0.0055 | 0.1282 | 0.0055 | 0.1002 |
| #4 | 0.0307 | 0.0220 | 0.0385 | 0.0233 | 0.0516 | 0.0055 | 0.0855 | 0.0164 | 0.1502 |
| #5 | 0.0044 | 0.0385 | 0.0385 | 0.0078 | 0.1032 | 0.0492 | 0.1709 | 0.0273 | 0.1502 |
| #6 | 0.0219 | 0.0330 | 0.0440 | 0.0207 | 0.0129 | 0.0219 | 0.1709 | 0.0109 | 0.1002 |

| | 2.Project Management | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Code | 2.1 | 2.2 | 2.3 | 2.4 | 2.5 | 2.6 | 2.7 | 2.8 | 2.9 |
| #1 | 0.2550 | 0.0201 | 0.0649 | 0.1748 | 0.2597 | 0.0156 | 0.2635 | 0.1098 | 0.2408 |
| #2 | 0.2869 | 0.0704 | 0.0325 | 0.0350 | 0.0649 | 0.0468 | 0.0376 | 0.0314 | 0.1204 |
| #3 | 0.2869 | 0.0805 | 0.1623 | 0.1748 | 0.1623 | 0.0078 | 0.3012 | 0.0157 | 0.2810 |
| #4 | 0.0956 | 0.0604 | 0.1623 | 0.2447 | 0.1948 | 0.0546 | 0.0376 | 0.0627 | 0.2810 |
| #5 | 0.2232 | 0.0402 | 0.1623 | 0.1049 | 0.2597 | 0.0390 | 0.0376 | 0.0470 | 0.2408 |
| #6 | 0.2869 | 0.0201 | 0.2273 | 0.2797 | 0.0325 | 0.0156 | 0.0376 | 0.0470 | 0.0401 |

| | 3. Petroleum Management | | | | | | |
|---|---|---|---|---|---|---|---|
| Code | 3.1 | 3.2 | 3.3 | | | | 3.4 |
| subs | | | 3.3.1 | 3.3.2 | 3.3.3 | 3.3.4 | |
| #1 | 1.5142 | 0.1453 | 0.0438 | 0.1533 | 0.0445 | 0.0041 | 1.3992 |
| #2 | 0.7571 | 1.0170 | 0.0438 | 0.1533 | 0.0049 | 0.0204 | 1.1193 |
| #3 | 0.3786 | 0.7264 | 0.0146 | 0.2452 | 0.0346 | 0.0286 | 0.8395 |
| #4 | 0.7571 | 0.5812 | 0.1169 | 0.2452 | 0.0148 | 0.0204 | 1.9588 |
| #5 | 1.1357 | 0.8717 | 0.1169 | 0.0307 | 0.0049 | 0.0367 | 1.9588 |
| #6 | 0.1893 | 0.5812 | 0.0438 | 0.0613 | 0.0346 | 0.0041 | 0.2798 |

## 6. Principal Component Analysis and TOPSIS

### *6.1. Results of PCA*

PCA is method that we can restructure our data specifically by reducing the number of variables. We conduct a principal component analysis to determine how many important components are present in the data. Rotate the components in order to make their interpretation more understandable in terms of a specific theory. This conclusion is supported by the scree scree plot in the scree plot we can easily notice that all 25 criteria could be reduced in only 5 new criteria that make our comparison faster and easier. In the table 13 rotated component matrix has been illustrated and the other analytic table were extracted and investigated carefully that lead us to the table 14's statistics for 5 new criteria.

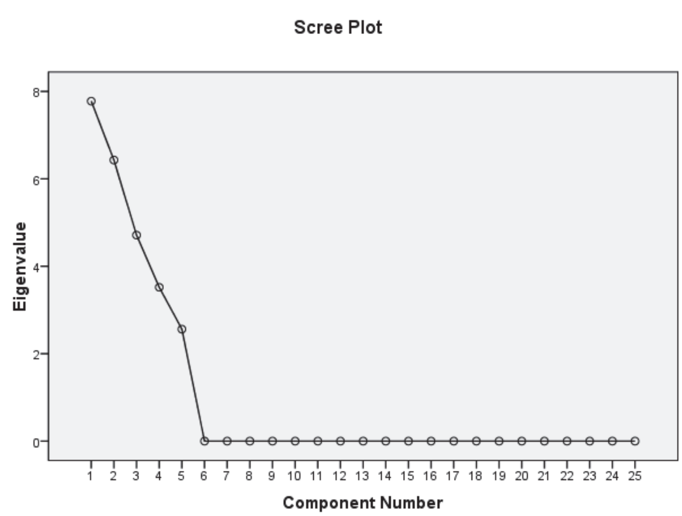


**Fig. 4.** The plot of PCA

**Table 13**
Rotated Component Matrix

| | Component | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| c1 | 0.155 | -0.170 | -0.559 | 0.091 | 0.792 |
| c2 | 0.252 | 0.439 | 0.722 | -0.120 | 0.457 |
| c3 | 0.640 | 0.006 | -0.082 | -0.180 | 0.742 |
| c4 | -0.404 | -0.150 | -0.832 | -0.336 | 0.096 |
| c5 | 0.550 | 0.287 | 0.275 | 0.487 | -0.550 |
| c6 | -0.259 | -0.034 | 0.844 | 0.259 | -0.391 |
| c7 | -0.283 | -0.428 | 0.858 | -0.016 | 0.041 |
| c8 | 0.204 | 0.641 | 0.589 | 0.374 | 0.246 |
| c9 | 0.641 | 0.724 | -0.009 | -0.010 | 0.255 |
| c10 | 0.229 | -0.760 | 0.291 | -0.486 | -0.222 |
| c11 | 0.743 | 0.004 | -0.654 | 0.140 | -0.034 |
| c12 | 0.019 | 0.093 | 0.273 | -0.055 | 0.956 |
| c13 | -0.575 | 0.009 | -0.096 | -0.062 | 0.810 |
| c14 | -0.181 | 0.034 | 0.206 | 0.947 | -0.163 |
| c15 | 0.181 | 0.918 | -0.188 | 0.049 | -0.295 |
| c16 | -0.133 | -0.856 | -0.245 | 0.435 | -0.019 |
| c17 | -0.893 | 0.065 | 0.143 | 0.295 | -0.300 |
| c18 | 0.085 | -0.012 | -0.285 | 0.954 | 0.021 |
| c19 | -0.365 | 0.088 | 0.251 | 0.591 | -0.668 |
| c20 | 0.910 | 0.298 | 0.032 | -0.272 | -0.094 |
| c21 | -0.021 | 0.874 | 0.253 | 0.407 | 0.079 |
| c22 | 0.011 | -0.130 | -0.942 | 0.299 | 0.080 |
| c23 | -0.617 | -0.731 | -0.081 | 0.015 | 0.280 |
| c24 | 0.838 | 0.213 | 0.101 | 0.492 | 0.031 |
| c25 | 0.020 | 0.599 | 0.023 | 0.748 | -0.282 |

**Table 14**
New criteria has extracted based on PCA

| Candidate | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|
| #1 | 0.0864 | 0.1077 | 0.0322 | 0.2503 | 0.0649 |
| #2 | 0.3563 | 0.0428 | 0.0185 | 0.0927 | 0.0325 |
| #3 | 0.2569 | 0.1079 | 0.0131 | 0.2217 | 0.1623 |
| #4 | 0.2214 | 0.0697 | 0.0144 | 0.2379 | 0.1623 |
| #5 | 0.3185 | 0.0645 | 0.0285 | 0.2503 | 0.1623 |
| #6 | 0.2108 | 0.0324 | 0.0213 | 0.0363 | 0.2273 |

### *6.2. Results of TOPSIS Method*

In this section we use TOPSIS method in order to choose the best project manager by using data that we calculated by analytic hierarchical process and principal component analysis in the previous part. The result of TOPSIS method is shown in Table 15. The TOPSIS method is explained completely in the previous section and we summarized the whole process and put the final result instead.

**Table 15**
TOPSIS result

| Candidate | $S^-$ | $S^*$ | C |
|---|---|---|---|
| #1 | 0.6149 | 0.6931 | 0.529911 |
| #2 | 0.7515 | 0.4587 | 0.379056 |
| #3 | 0.4249 | 0.7089 | 0.625213 |
| #4 | 0.4738 | 0.6157 | 0.565157 |
| #5 | 0.3045 | 0.7473 | 0.710499 |
| #6 | 0.6675 | 0.5835 | 0.466441 |

**#5> #3>#4>#1>#6>#2**

## 7. Validation

VIKOR method is one of the most usable multi-criteria decision making methods. It concentrates on ranking a set of alternatives in terms of a set of criteria. Also the criteria could be in conflict with each other. Overall the method is very flexible and can help the decision maker make the final decision better than other techniques (Hwang & Yoon, 1981). Büyüközkan and Gülçin (2015) evaluated a product development patterns using integrated AHP-VIKOR model, they proposed their model in product development process and concentreated in their model by selecting a suitable patterns for effective PD. A part of their method is similar to our approach. This multi-criteria method is based on Lp-metric to use aggregating function in order to reach compromise (Hwang & Yu, 1981).

$$L_{pi} = \left\{ \sum_{j=1}^{n} \left[ (f_j^* - f_{ij}) \big/ (f_j^* - f_j^-) \right]^p \right\}^{1/p} \quad 1 \le p \le \infty; i = 1,2,3,\ldots,m. \tag{9}$$

In the VIKOR method $L_{1,i}$ (as $S_i$ )and $L_{\infty,i}$ (as $R_i$ )are used to formulate ranking measure. The solution obtained by min $S_i$ is with a maximum group utility (‘‘majority” rule), and the solution obtained by min

$R_i$ is with a minimum individual regret of the "opponent". Assuming that each alternative is evaluated by each criterion function, the compromise ranking could be performed by comparing the measure of closeness to the ideal alternative. The various $m$ alternatives are denoted as $A_1, A_2, A_3, ..., A_m$. For alternative $A_i$, the rating of the $j$th aspect is denoted by $f_{ij}$, i.e. $f_{ij}$ is the value of $j$th criterion function for the alternative $A_i$; $n$ is the number of criteria. The compromise ranking algorithm of the VIKOR method has the following steps:

(1) Determine the best $f_j^*$ and the worst $f_j^-$ values of all criterion functions $j = 1,2,...,n$. If the jth function represents a benefit then:

$$f_j^* = \max_i f_{ij}, f_j^- = \min_i f_{ij} \tag{10}$$

(2) Compute the values $S_i$ and $R_i$; $i = 1,2,...,m$, by these relations:

$$S_i = \sum_{j=1}^{n} w_j (f_j^* - f_{ij})/(f_j^* - f_j^-) \tag{11}$$

$$R_i = \max_j w_j (f_j^* - f_{ij})/(f_j^* - f_j^-) \tag{12}$$

where $w_j$ are the weights of criteria, expressing their relative importance.

(3) Compute the values $Q_i : i = 1,2,...,m$, by the following relation:

$$Q_i = v(S_i - S^*)/(S^- - S^*) + (1-v)(R_i - R^*)/(R^- - R^*) \tag{13}$$

where

$$S^* = \min_i S_i, S^- = \max_i S_i \tag{14}$$

$$R^* = \min_i R_i, R^- = \max_i R_i \tag{15}$$

$v$ is introduced as weight of the strategy of ''the majority of criteria" (or ''the maximum group utility"), here suppose that $v = 0.5$.

(4) Rank the alternatives, sorting by the values $S$, $R$ and $Q$ in decreasing order. The results are three ranking lists.

(5) Propose as a compromise solution the alternative $A'$, which is ranked the best by the measure $Q$ (Minimum) if the following two conditions are satisfied:

C1. Acceptable advantage: $Q(A'') - Q(A') \geq DQ$, where $A''$ is the alternative with second position in the ranking list by Q;DQ=1/(m-1); $m$ is the number of alternatives.

C2. Acceptable stability in decision making: Alternative $A'$ must also be the best ranked by $S$ or/and $R$. This compromise solution is stable within a decision making process, which could be ''voting by majority rule" (when $v > 0.5$ is needed), or ''by consensus" $v \approx 0.5$, or ''with veto" $(v < 0.5)$. Here, $v$ is the weight of the decision making strategy ''the majority of criteria" (or ''the maximum group utility"). The results of VIKOR is show in the following table briefly:

**Table 16**
VIKOR result

| | R | Q |
|---|---|---|
| Rank1 Alter5 R = 0.054086 | Rank1 Alter5 S = 0.23329 | Rank1 Alter5 Q = 0 |
| Rank2 Alter3 R = 0.10817 | Rank2 Alter3 S = 0.33564 | Rank2 Alter3 Q = 0.21768 |
| Rank3 Alter1 R = 0.1399 | Rank3 Alter1 S = 0.3967 | Rank3 Alter1 Q = 0.35831 |
| Rank4 Alter4 R = 0.1453 | Rank4 Alter4 S = 0.50071 | Rank4 Alter4Q = 0.4458 |
| Rank5 Alter2 R = 0.18653 | Rank5 Alter2 S = 0.52124 | Rank5 Alter2 Q = 0.56873 |
| Rank6 Alter6 R = 0.2798 | Rank6 Alter6 S = 0.7562 | Rank6 Alter6 Q = 1 |

## 8. Discussion and conclusion

The ranking also shows that criteria number five is the most qualify alternative for the project management in Petroleum industry. The difference between VIKOR method and PCA-TOPSIS has shown in Table 16. It shows that the first and the second candidate are not different in both methods but other candidates ranking are different.

**Table 16**
Comparing the result

| | |
|---|---|
| **#5> #3>#4>#1>#6>#2** | PCA-TOPSIS |
| **#5> #3>#1>#4>#2>#6** | VIKOR |

Staffing problem is one of the most challenging activities in the organizations, especially if the criteria or alternatives are large. The process of calculating is going to be very hard and time consuming. The proposed model is very useful for staffing problem that have many criteria and alternatives. This method is based on statistical process that reduces the size of criteria and extract the effective criteria and make the selecting process easier. The method could be verified by any MCDM methods. In this paper, we have tested our model by VIKOR method that is a very common method in multi criteria decision making problems. The results have shown that there was a little difference in the results of VIKOR and PCA-TOPSIS method and they were not significant enough to affect the process of selecting manger of the petroleum industry. The proposed process is very helpful when we encounter too many criteria and we do not know that all which ones are might not be effective or which ones are very crucial. PCA can reduce the size of criteria and make the process very easily to deal with.

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