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A hybrid multi criteria decision analysis for engineering project manager evaluation

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A B S T R A C T

Engineering project manager plays dynamic roles in managing projects. Therefore, selecting a qualified candidate to project manager position should be considered carefully. Moreover, it plays a significant role in the success of any engineering firms. Traditional project managers evaluating decision-making methods are usually based on subjective opinions of experts, resulting in irrational and inappropriate decisions. This paper introduces a multi-criteria decision analysis solution for engineering project manager assessment by integrating Analytic Hierarchy Process (AHP) methodology and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) technique. This approach is found to be useful when dealing with plenty of evaluation criteria and project manager candidates.

1. Introduction

It is a challenged decision-making process for any organization to select an eligible candidate for a management position because his or her actions significantly impact on its achievements (Gatewood et al., 2015). Also, if unqualified people are chosen for a management position, this may discourage other personnel who are more qualified and appropriate for the position. Furthermore, their motivation to work and devote to the company shall be eliminated. Especially, in large-scale enterprises, the demand for the engineering projects implementation within the enterprise is inevitable (Bagherinia and Olapour, 2016; Nguyen et al., 2017a). In those organizations, projects are typically associated with a tremendous amount of investment capital as well as time, quality, and budget constraints (Ullah et al., 2016). A key success factor of their projects is a project manager (Mohammadi et al., 2014; Sadeghi et al., 2014).

Project manager plays an extremely significant role in the success of projects. The project manager must be able to organize and operate their projects by using their knowledge, experience, and necessary personal skills to achieve all project objectives (El-Sabaa, 2001; Odusami, 2002). The selection of qualified project managers is a challenging problem for any firms. Normally, it depends on company's specific objectives, the availability of human resources and the preferences of decision makers (Nguyen et al., 2017b). Yet, the previous studies on project manager selection models have been very limited. Most of the existing evaluating and decision-making models are usually based on subjective opinions of decision makers, resulting in irrational and inappropriate decisions (Behzadian et al., 2012; Tran, 2016). In addition, the models also ignore the factors concerning uncertainty and the importance of assessors (Babaee Asil and Fanati Rashidi, 2015; Vavan and Braike, 2015). To overcome these disadvantages, we propose a quantitative model for project manager selection by using the AHP and TOPSIS method.

2. Research background

The first step to building the selection project manager model is to identify key selection criteria. Typically, different researchers and companies have different sets of selection criteria. For example, Pinto (2015) ranked the nine most critical skills of effective project managers in order of decreased importance including leader competencies, visionary, technically competent, decisive, communication skills, motivator skills, stands up to top management when necessary, supports project members and encourages new ideas. Similarly, Meredith and Mantel (2011) summarized the essential requirements and skills of a project

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manager into six groups including communication skills, technical background skills, team skills, coping skills, organization skills and leadership skills. In more detail, Rashidi et al. (2010) pointed out twenty-three selection criteria and divided into four groups: technical and professional background, educational background, demographic features and general management abilities. Mohammadi et al. (2014) suggested eighteen selection criteria in evaluating project manager applicants, including job experience, academic achievement, communication skills, Microsoft project software, planning skill, organizing skill, leading skill, controlling and monitoring skill, conducting meetings, record keeping, time management, property management, worker welfare management, rules and regulation, problem solving skills, decision analysis, multi-tasking, and correspondence. However, Goodwin (1993), Pheng and Chuan (2006) proved that conceptual skills, human skills, and technical expertise are the main basic requirements. Despite different viewpoints of different researchers, in general, there are many similar criteria in assessing the project manager. Also, the selection criteria will depend on the project's characteristics and scale as well as the organization's objectives and vision.

In this research, we identified engineering project manager selection criteria using in-depth interviews with seventy-two experts in Vietnam companies. The results showed that there are eighteen criteria divided into four main groups in the selection process as summarized in Table 1.

Table 1: Project manager selection criteria

	Basic requirements
1	Experience managing and operating similar projects
2	Project management academic background
3	Knowledge of law and regulation
4	English languages and IT capability
5	Physical and mental health
	Project management skills
6	Planning skills
7	Organizing skills
8	Leading skills
9	Controlling and monitoring skills
	Administration skills
10	Conducting meetings skills
11	Negotiations skills
12	Human resources management skills
13	Time management skills
	Personal skills
14	Communication skills
15	Decision-making skills
16	Problem-solving skills
17	Teamwork skills
18	Training skills

3. Research methodology

3.1. AHP

The Analytic Hierarchy Process (AHP), introduced by Saaty (2005) was known as a multi-criteria decision analysis method. It is widely applied in outstanding works of various fields relating to best option selection, conflict solution, resource allocation and optimization of the decision-making process (Nguyen et al., 2016). In this study, the AHP is employed to establish weights for project manager evaluation criteria in the hierarchical model.

Step 1. Hierarchy Construction: Hierarchy is established by breaking down the overall goal into basic elements. The review of literature and authors' critical judgments has led to the suggestion of the hierarchical model including four levels and eighteen sub-levels of project manager indicators.

Step 2. The performance of in-depth interviews with experts based on pairwise comparison matrix. In this step, the relative importance of each element at its level is evaluated. The philosophy of weights calculation behind the AHP is to compare pairwise with a scale of 1-9 as indicated in Table 2.

Table 2: The fundamental Saaty (2005) scale of 1-9

Scale	Description
1	Two activities are equally important to the goal
2	One activity are equally to moderately important to the goal
3	One activity is moderately favoured to another
4	One activity is moderately to strongly favoured to another
5	One activity is strongly favoured to another
6	One activity is strongly to very strongly favoured to another
7	One activity is very strongly favoured to another
8	One activity is very to extremely strongly favoured to another
9	One activity is extremely favoured to another

Step 3. Estimation of priority vector for every factor and evaluation of consistency ratio (CR) of experts' judgments.

The factor's priorities are acquired by averaging the row values of the normalized matrix. In practical problems, we are not always able to establish the bridging relation in pairwise comparisons. For example, alternative A may be at a higher rank than alternative B; alternative B may be superior to alternative C, but this does not always mean that A is a better option than C. This shows the realistic characteristic of practical problems which is called inconsistency. Inconsistency is real, but its value should not be too high. Otherwise, the evaluation is not accurate. The consistency ratio is used to assess the inconsistency of each level. If it is equal or lower than 0.1, it means that the decision maker's evaluation is relatively consistent. Otherwise, re-evaluation of appropriate level should be carried out. The consistency ratio (CR) was calculated as a ratio of consistency index (CI) divided by random index (RI). Table 3 presents the random consistency index.

Step 4. Sensitivity analysis: A study of how changes in the weights of the criteria could affect the result is done to understand the rationale behind the obtained results. Based on the synthesis results and sensitivity analysis, a decision can be made.

3.2. TOPSIS

In this research, the proposed TOPSIS procedure to rank project manager candidate is conducted with the following steps (Ju and Wang, 2012; Önüt et al., 2010):

Step one. Develop the normalized decision matrix of n candidates on m criteria by using distributive normalization (Eq. 1):

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{n} x_{ij}^2}} \tag{1}$$

where, r_{ij} stands for the normalized value; i=1,2, 3, ..., m and j = 1, 2, 3,..., n.

Step two. Calculate the weighted normalized decision matrix (Eq. 2).

$$v_{ij} = w_j * r_{ij} \tag{2}$$

where, w_i stands for the weight of the individual criterion; i = 1, ... , m and j = 1, 2, ..., n.

Step three. Identify the positive ideal solution and the negative one. For the positive ideal solution (Eq. 3):

$$V^+ = (v_1^+, \ldots, v_j^+, \ldots, v_n^+) \tag{3}$$

and for the negative ideal solution (Eq. 4):

$$V^- = (v_1^-, \ldots, v_j^-, \ldots, v_n^-) \tag{4}$$

where, $v_j^- = min_i(v_{ij})$ if C_j is to be minimized and $v_j^+ = max_i(v_{ij})$ if C_j is to be maximized.

Step four. Calculate the distance for each alternative to both the positive ideal solution point (Eq. 5):

$$d_i^+ = \sqrt{\sum_{j=1}^{n}(v_j^+ - v_{ij})^2} \tag{5}$$

and the negative ideal one (Eq. 6):

$$d_i^- = \sqrt{\sum_{j=1}^{n}(v_j^- - v_{ij})^2} \tag{6}$$

where, i = 1,2, ... , m; $v_j^+ = max_i(v_{ij})$ and $v_j^- = min_i(v_{ij})$.

Step five. Calculate each alternative's relative closeness coefficient to the ideal solution (Eq. 7):

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-} \tag{7}$$

Step six. Order the alternatives and choose the one with a maximum value of closeness coefficients.

4. Numerical illustration

The effectiveness of these methods is discussed through a case study in one Construction Company in Vietnam. To be simple for illustrative purposes only, the group of decision makers considered four main criteria with their significant weights calculated by AHP methodology as presented in Table 4.

Five engineering project manager candidates were selected and evaluated for their capacity for project management position with the scores in Table 5.

Table 3: Random consistency index

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Table 4: Main criteria for project manager selection problem

	Main criteria	Weight
BAR	Basic requirements	0.42
PMS	Project management skills	0.37
ADS	Administration skills	0.12
PES	Personal skills	0.09

Table 5: The evaluation scores for engineering project manager candidates

EPM	BAR	PMS	ADS	PES
EPM_1	85	70	70	60
EPM_2	75	85	90	55
EPM_3	70	85	75	90
EPM_4	70	65	70	60
EPM_5	75	80	70	85

From the Table 5, we can see that the engineering project manager candidate EPM_4 has the evaluation scores dominated by other candidates. Therefore, in the screening step, that alternative was removed out of further calculation based on TOPSIS method. Then evaluators assessed the remaining project manager candidates by using TOPSIS procedure. The results show that the engineering project manager candidate EPM_2 is the best because it gains the highest relative closeness coefficient score (0.54) among all project manager candidates.

5. Conclusion

This paper proposes a quantitative approach to select a project manager by using multiple criteria decision-making techniques, namely AHP and TOPSIS. We believe that the proposed method is a very useful decision-making tool for engineering project manager selection challenges. First, this method can provide an even more structured way and reduce the time in evaluation and selection process of an engineering project manager. Compared with traditional methods such as scoring technique, AHP and TOPSIS techniques are very useful when the number of assessment criteria, as well as the number of project manager candidates, is significant. Moreover, it also takes into account the importance of the role and expertise of decision-makers in the evaluation process.

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