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EXTENDED ABSTRACT

Developing Multiple Criteria Decision-Making Model based on the Best-Worst-VIKOR Method for Evaluation of Civil Projects Contractors; Case Study of Civil Projects in Southern Khorasan Province

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1. Introduction

In large-scale civil projects such as urban gas-supply projects, one of the most important concerns is a selection of appropriate contractor for performing projects. In order to evaluate contractors' performance and select a more qualified contractor, the appropriate criteria for assessing contractors should be identified (De Araújo et al., 2018). Accordingly, a reliable methodology should be used for assigning weights to criteria, as well as a comprehensive method should be analyzed for ranking contractors (Hasnain et al., 2018a).

In this research, the Best-Worst Method (BWM) is utilized for assigning weights to contractors' evaluation criteria based on using a linear optimization model, which improves the previous weighting methods (Rezaei, 2016). In addition, the Fuzzy VIseKriterijumska Optimizacija I Kompromisno Resenje (FVIKOR) method is analyzed in order to score for contractors based on proximity to ideal solution and bilateral agreement through concessions, which uses simple and short calculations for evaluating contractors with respect to criteria, and causes a high degree of consistency in final ranking results (Gupta, 2018).

Therefore, in this study, a novel approach based on a combination of the BWM and the FVIKOR methods is developed, in which a systematic and applicable algorithm is used for choosing the final evaluation criteria, the selected criteria are weighted, and the contractors of gas-supply civil projects are ranked. In application, regarding that the gas company of Southern Khorasan province is faced challenges and concerns in the process of selecting qualified contractors for gas-supply civil projects, the choose of the more qualified contractor in one of the most important urban gas-supply projects of this company is investigated.

2. Methodology

2.1. Best-Worst Method for weighting criteria

In this study, based on the BWM methodology, the following steps are implemented using linear optimization (Eq. 1) (Rezaei, 2016):
Step 1. Creating a decision criteria system $\{c_1, c_2, \dots, c_n\}$;
Step 2. Determining the best criterion (c_B) and the worst criterion (w_B) from the set of criteria in DMs' opinion;
Step 3. Implementing comparisons for the best criterion $\{A_B = (a_{B1}, a_{B2}, \dots, a_{Bn})^T\}$ in DMs' viewpoint;
Step 4. Implementing comparisons for the worst criterion $\{A_w = (a_{1W}, a_{2W}, \dots, a_{nW})^T\}$ in DMs' viewpoint;
Step 5. Calculating the optimal weights vector of $(w_1^*, w_2^*, \dots, w_n^*)$.

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$$\begin{aligned} &min\ \xi^L \\ &S.t. \\ &\left|w_B - a_{Bj}w_j\right| \le \xi^L, for\ all\ j\ ;\ \left|w_j - a_{jW}w_W\right| \le \xi^L, for\ all\ j\ ;\ \sum_j w_j = 1\ , w_j \ge 0, for\ all\ j \end{aligned} \quad (1)$$

where, w_B is the weight of the best criterion, w_w is the weight of the worst criterion, w_j is the weight of the j^{th} criterion, a_{Bj} is the priority of the best-selected criterion into the j^{th} criterion, and a_{jW} is the priority of the j^{th} criterion into the worst selected criterion in each DM's viewpoint. Also, ξ^L is $\{|w_B - a_{Bj}w_j|, |w_j - a_{jW}w_W|\}$ that its maximum value should be minimized for all criteria. The optimal weights vector of $(w_1^*, w_2^*, \dots, w_n^*)$ is the solution of the linear optimization model of (Eq. 1).

2.2. FVIKOR method for scoring alternatives

The FVIKOR method is a compromise ranking method that is used when there are several conflicting criteria (Opricovic, 1998). Accordingly, this method includes the following steps and uses (Eq. 2) (Gupta, 2018):

Step 1. Forming a pair-wise comparison matrix for each alternative;
Step 2. Calculating the average decision matrix;
Step 3. Calculating the evaluation values of the best and worst alternatives;
Step 4. Calculating the alternatives' distances from ideal and anti-ideal solutions;
Step 5. Calculating the amount of Q_i;
Step 6. Ranking the alternatives based on descending Q_i values;

$$Q_i = v\left[\frac{S_i - S^*}{S^- - S^*}\right] + (1 - v)\left[\frac{R_i - R^*}{R^- - R^*}\right] \quad (2)$$

Where, S_i indicates the distance between the i^{th} alternative and the ideal solution, R_i is the distance between the i^{th} alternative and the anti-ideal solution, and $S^- = \max_i S_i$, $S^* = \min_i S_i$, and $R^- = \max_i R_i$, $R^* = \min_i R_i$. Also, $v \in [0,1]$, as the FVIKOR parameter, is used to indicate the maximum group desirability strategy. The alternatives are ranked based on the descending order of the Q_i values.

3. Results and discussion

3.1. BWM weighing results for the evaluation criteria

In this study, in order to achieve real results for evaluating the contractors, a group decision-making process is analyzed based on the opinions of the DMs' committee members, including the experts of Southern Khorasan Province Gas Company, also some of the faculty members.

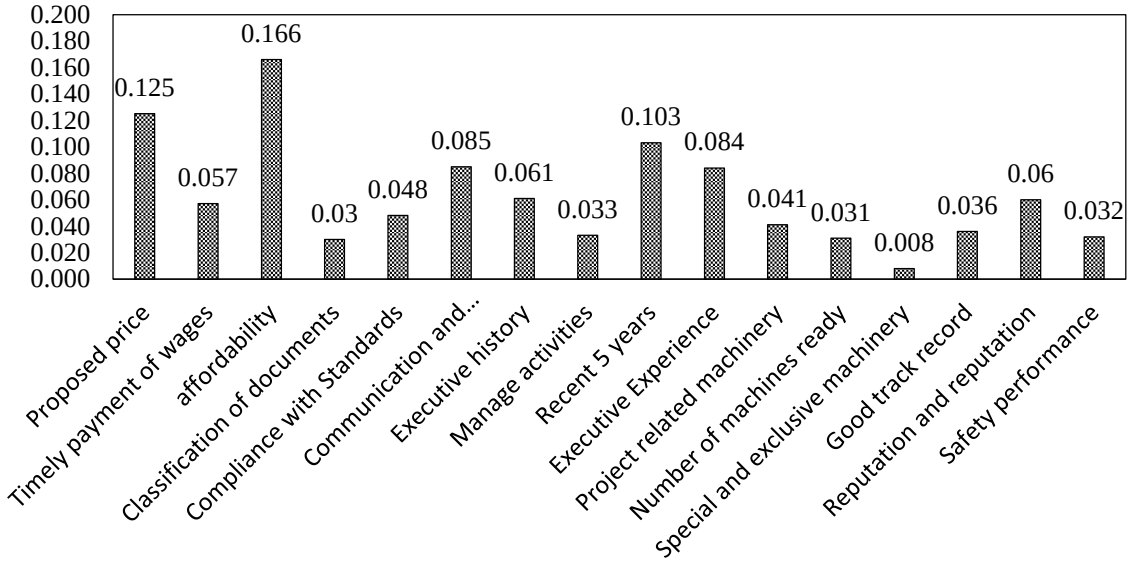

Fig. 1. The BWM weights of criteria for evaluating contractors in the Southern Khorasan gas-supply civil projects

This process leads to selecting the final effective criteria and evaluating the competency of contractors with respect to that selected criteria. Accordingly, first, based on the BWM analysis results presented in Fig. 1, the three criteria have the highest importance degrees for evaluation of the contractors, which include affordability, the proposed price and the implemented projects in the recent 5 years. Through the same, the three criteria that have the lowest importance include special and exclusive machinery, the classification of documents, and the number of ready-made machineries.

3.2. FVIKOR scoring results for contractors' ranking

After that, based on the FVIKOR analysis results presented in Table 1, the scores of Q and ranking of the contractors are varied with changes in the FVIKOR parameters of v. Accordingly, for parameters of $v \in [0,0.4]$, the highest rank is assigned to the first contractor with the minimum value of Q. Also, the lowest score is assigned to contractor 3 with the maximum value of Q. For parameters of $v \in [0.5,0.7]$, the highest rank is assigned to contractor 1, while the lowest score is assigned to the contractor 2. For parameters of $v \in [0.6,1.0]$, the highest rank is assigned to the contractor 4, and the lowest score is assigned to the contractor 2.

Table 1. The FVIKOR scores and ranking of the contractors in the Southern Khorasan gas-supply civil projects

Contractor	v =0		v =0.1		v =0.2		v =0.3		v =0.4		v =0.5	
	Q	*Rank*	*Q*	*Rank*	*Q*	*Rank*	*Q*	*Rank*	*Q*	*Rank*	*Q*	*Rank*
Contractor 1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1
Contractor 2	0.904	3	0.899	3	0.893	3	0.887	3	0.881	3	0.875	4
Contractor 3	1.372	5	1.272	5	1.172	5	1.072	5	0.972	4	0.872	3
Contractor 4	0.346	2	0.356	2	0.365	2	0.375	2	0.385	2	0.395	2
Contractor 5	1.000	4	1.000	4	1.000	4	1.000	4	1.000	5	1.000	5
Contractor	v =0.6		v =0.7		v =0.8		v =0.9		v =1.0			
	Q	*Rank*	*Q*	*Rank*	*Q*	*Rank*	*Q*	*Rank*	*Q*	*Rank*		
Contractor 1	0.000	1	0.000	1	0.000	1	0.000	1	0.000	1		
Contractor 2	0.869	4	0.863	4	0.858	4	0.852	4	0.852	4		
Contractor 3	0.772	3	0.672	3	0.572	3	0.472	3	0.355	2		
Contractor 4	0.405	2	0.415	2	0.425	2	0.434	2	0.439	3		
Contractor 5	1.000	5	1.000	5	1.000	5	1.000	5	1.000	5		

4. Conclusions

In this study, a combined Multi-Criteria Decision-Making (MCDM) process has been used for prioritizing the contractors of the Southern Khorasan gas-supply civil projects. This process includes the BWM method for determining the criteria importance and the FVIKOR method for scoring the contractors. According to the BWM results, the economic and financial criterion has the highest weight (0.348), while having machinery and equipment has the lowest weight (0.080). Based on the FVIKOR results, the contractor 1 has been selected as the first contractor and the contractor 4 has been ranked as the second contractor for the parameters of $v \in [0,0.7]$. Also, for the parameters of $v \in [0.8,1.0]$, the contractor 1 has been chosen as the first contractor and the contractor 4 has been ranked as the second contractor. In the real case, according to an interview with the manager and experts of the company, the contractor 4 has been chosen for implementing the gas-supply civil projects and the contractor 1 has obtained the second rank. Therefore, the proposed MCDM result and the real case result are almost the same and the contractors 1 and 4 are competitive. In the real case, the reason for choosing the contractor 4 is just related to its lowest proposed price in comparison with the contractor 1, while by using the proposed methodology, all of evaluation criteria have been considered and the related results are more logical and reliable. In classification, it can be said that using the proposed method of this research can provide comprehensive management proposals for oriented and appropriate to the Southern Khorasan gas company as well as other public and private organizations for the process of selecting the qualified contractor or consultant. In order to develop future research, it is suggested that fuzzy uncertainty conditions are considered for the proposed MCDM input values. Also, a heterogeneous consensus-based group decision-making process can be considered through the process.

5. References

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