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Contractor Pre-qualification Selection by TOPSIS Method

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Abstract: ***Contractor selection has become challenging as the number of decision alternatives and conflicting attributes increase. The paper attempt to employ TOPSIS Method and apply it to the study conducted by Al-Harbi (2001) with the intention of finding a better Selection. TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) was developed by Hwang and Yoon (1981), and it is one of the Multi Criteria Decision Analysis or Multi Criteria Decision Methods for resolving real-world decision problems satisfactorily. Results shows that 60% of the contractors selected had their ranking reversed, while 40% remain unchanged. Findings also, reveal that the first and fifth selected contractors maintain their rank. The paper is the first research work to use and applies a different approach on the same contract pre-qualification selection.***

Keywords: Multi-Criteria Decision Analysis Method, Analytical Hierarchical Process

1. Introduction

TOPSIS 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. It is a method of compensatory aggregation that compares a set of alternatives by identifying weights for each criterion, normalizing scores for each criterion and calculating the geometric distance between each alternative and the ideal alternative, which is the best score in each criterion. An assumption of TOPSIS is that the criteria are monotonically increasing or decreasing. Normalization is usually required as the parameter or criteria is often of inappropriate dimensions in multi-criteria problems. Compensatory methods such as TOPSIS allow trade-offs between criteria, where a poor result in one criterion can be negated by a good result in another criterion. This provides a more realistic form of modeling than no compensatory methods, which include or exclude alternative solutions based on hard cut-offs.

Table 1: Hierarchical Representation of Criteria

S. No.	Criteria	Abbreviation
1	Experience	EXP
2	Financial Stability	FSB
3	Quality Performance	QPF
4	Manpower Resource	MPR
5	Equipment Resource	EQR
6	Current Works Load	CWL

Table 1 shows the criteria used in the paper, each criteria is abbreviated as shown in the table.

The numbers of alternatives (contractors) were adopted from Al-Harbi (2001) paper. A contractor is abbreviated as CTR in the paper. The rest of the paper is organized as follows: section 1 presents the Introduction. Literature is review in section 2. TOPSIS methodology is described in section 3, and Section 4 presents the results. Finally, the conclusion is presented in section 5.

2. Literature Review

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a multi-criteria decision analysis method, which was originally developed by (Hwang and Yoon, 1981) with further developments by (Yoon and Hwang, 1985), and (Hwang et al., 1993).

Karim and Karmaker (2016) conducted a study on TOPSIS application. A machine is presented as decision alternatives base on seven attributes. Each criteria is further sub divided into twenty six sub criteria. A decision is require to select one machine out of three. The decision problem was formulated and solved. The results selects the most suitable machine among the three considered for selection.

Wang and Luo (2009) Examined rank reversal in several Multi-Criteria Decision Analysis Method, these includes Borda kendall Method, Analytical Hierarchical Process (AHP), Simple additive weight- ing Method (SAW), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Cross efficiency of data envelopment analysis (DEA). Results clearly, established the existence of rank reversal in TOPSIS as a result of addition or deletion of a decision alternative, indeed is one of the disadvantage of the method.

TOPSIS attempts to indicate the best alternative that simultaneously has the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution. The positive ideal solution is a solution that tries to maximize the profit criteria and minimize the cost criteria, whereas the negative ideal solution is just opposite to previous one. According to (Wang and Chen, 2007), the positive ideal solution is composed of all the good values attainable of criteria, whereas the negative ideal solution consists of all worst values attainable of criteria. In the TOPSIS method, precise scores that each alternative receives from all the criteria are used in the formation of a decision matrix and normalized decision matrix. By taking into consideration the rates of all attributes, positive and negative ideal solutions are found. By comparing the distance coefficient of each alternative, the preference order of the alternatives is determined.

3. Methodology

For the assessment of contractor's selection, one of the MCDM methods named TOPSIS has been applied in this research. In this section, TOPSIS method is explained.

3.1 TOPSIS Algorithm

The stepwise procedure of (Hwang and Yoon, 1981) for implementing TOPSIS is presented as follows:

Step 1 Construct normalized decision matrix of beneficial and non-beneficial criteria.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{J} x_{ij}^2}}, \quad j = 1,2,3,\dots,J : i = 1,2,3,\dots,n \qquad (1)$$

Step 2 Construct the weighted normalized decision matrix by multiplying the weights w_i of evaluation criteria with the normalized decision matrix r_{ij} .

$$r_{ij} = w_i * x_{ij\,.}\ j = 1,2,3,\dots,J; i = 1,2,3,\dots,n \qquad (2)$$

Step 3 Determined the Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS)

$$A^* = \{v_1^*, v_2^*, v_1^*, \dots, v_n^*\}\ maximum\ Values \qquad (3)$$
$$where\ v_i^* = \{max(v_{ij})\ if\ j \in J;\ min(v_{ij})\ if\ j \in J^-\}$$

$$A^- = \{v_1^-, v_2^-, v_1^-, \dots, v_n^-\}\ minimum\ Value \qquad (4)$$
$$where\ v_i^- = \{min(v_{ij})\ if\ j \in J;\ max(v_{ij})\ if\ j \in J^-\}$$

Step 4 Calculate the separation measures of each alternatives from PIS and NIS

$$d_i^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2}, \quad j = 1,2,3,\dots,J \qquad (5)$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}, \quad j = 1,2,3,\dots,J \qquad (6)$$

Step 5 Calculate the relative closeness coefficient to the ideal solution of each alternative

$$CC_i = \frac{d_i^-}{d_i^* - d_i^-} \quad i = 1,2,3,\dots,J. \qquad (7)$$

Step 6 Based on the decreasing values of closeness coefficient, alternatives are ranked from most valuable to worst. The alternatives having highest closeness coefficient CC_i is selected

4. Contractor Selection by TOPSIS Method

This numerical example was adopted from the research work of Al-Harbi (2001). The application of TOPSIS approach commence as follows: Table 2, presents decision matrix. The matrix was obtained by pairwise comparison developed by Saaty (1980) in his work on AHP

Table 2: Decision Matrix for TOPSIS Method

	EXP	FSB	QPF	MPR	EQR	CWL
CTR1	8	6	9	9	8	5
CTR2	7	7	6	7	9	7
CTR3	5	9	9	8	6	6
CTR4	9	8	9	6	8	9
CTR5	6	5	2	5	7	8

Table 3, shows the pair-wise comparisation of the decision criterion. It was formulated based on AHP Methodology (Saaty, 1980). Use equation (8) on Table 3, to normalize it. Table 4, is obtain by normalizing Tale 3.

Table 3: Pair-wise comparison matrix for the six criteria

	EXP	FSB	QPF	MPR	EQR	CWL
EXP	1	2	3	6	6	5
FSB	1/2	1	3	6	6	5
QPF	1/3	1/3	1	4	4	3
MPR	1/6	1/6	1/4	1	2	1/2
EQR	1/6	1/6	1/4	1/2	1	1/4
CWL	1/5	1/5	1/3	2	4	1

The level of inconsistency of Table 3, is acceptable.

	EXP	FSB	QPF	MPR	EQR	CWL
EXP	0.42	0.52	0.38	0.31	0.26	0.34
FSB	0.21	0.26	0.38	0.31	0.26	0.34
QPF	0.14	0.09	0.13	0.21	0.17	0.20
MPR	0.07	0.04	0.03	0.05	0.09	0.03
EQR	0.07	0.04	0.03	0.03	0.04	0.02
CWL	0.08	0.05	0.04	0.10	0.17	0.07

$$C_{ij} = \frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}}, \quad i = 1,2,3,\dots,n; j = 1,2,3,\dots,n \qquad (8)$$

Then the priority weights are calculated by using equation (9).

$$w_i = \frac{\sum_{j=1}^{n} c_{ij}}{n}, \quad i = 1,2,3,\dots,n \qquad (9)$$

$$W = [w_1, w_2, w_3, \dots,]^T$$

$$W_1 = (2.23)\frac{1}{6} = 0.372, W_4 = (0.32)\frac{1}{6} = 0.053$$
$$W_2 = (1.76)\frac{1}{6} = 0.293, W_5 = (0.23)\frac{1}{6} = 0.039$$
$$W_3 = (0.94)\frac{1}{6} = 0.156, W_6 = (0.52)\frac{1}{6} = 0.087$$

The normalized weight vector with respect to the main criteria is as follows:

W = (0.372, 0.293, 0.156, 0.053, 0.039, 0.087).

Table 5: Calculation steps of the TOPSIS Method for the contractor selection process

S. No	Contractor	PISA ($A^{\square}$)	NISA (A^-)
1	CTR1	0.060	0.100
2	CTR2	0.067	0.071
3	CTR3	0.064	0.099
4	CTR4	0.030	0.126
5	CTR5	0.122	0.024

$$A^* = \{0.210, 0.165, 0.083, 0.030, 0.020, 0.027\}$$
$$A^- = \{0.116, 0.092, 0.019, 0.017, 0.014, 0.049\}$$

The histogram is a pictorial representation of both the benefit and negative attributes use in the paper. The horizontal axis showing the criteria while the vertical axis depicts their respective weights. Experience has the highest weight of 37%, follow by financial stability 29%, follow by quality performance 16%, then current workload 9%, then manpower resource 5%, and finally the least is equipment resources with 4%.

4.1 Contractor Ranking by TOPSIS

TOPSIS Method is applied to Al-Harbi (2001) contractor pre-qualification selection study.

Table 6: Comparative analysis

	TOPSIS Ranking CC_i		AHP Ranking Priority	
CTR1	0.627	2nd	0.222	3rd
CTR2	0.516	3rd	0.201	4th
CTR3	0.514	4th	0.241	2nd
CTR4	0.806	1st	0.288	1st
CTR5	0.167	5th	0.046	5th

5. Conclusion

Selection of contractor necessitates complex decision making positions that require apprehensive abilities and technique to form sound decisions, so as not to select a bad contractor that would fail in project implementation

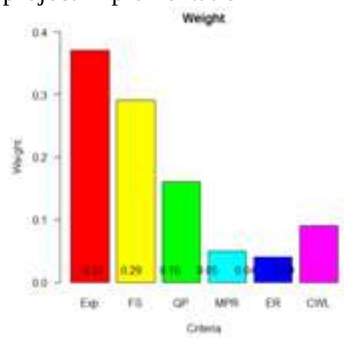

Figure 1: Normalized weights of criteria

The paper has presented TOPSIS as a decision-making tool that allows the consideration of multiple attributes. TOPSIS assume that criteria is monotonically increasing or decreasing. The positive ideal solution is a solution that tries to maximize the profit criteria and minimize the cost criteria, whereas the negative ideal solution is just the opposite to previous one. Results shows that 60% of the contractors selected had their ranking reversed, while 40% maintain their ranking. Findings also, reveal that the first and the fifth contractor selected by Al-Harbi (2001) is also the first and the fifth selected in the paper. The proposed method is also effective in a group decision environment where it is found to be difficult to come to a disputable point individually. Thus, it will also help in future researches as well. Besides, the proposed methods in this study, some other MCDM Methods such as BORDA KANDELL, MACBETH, PROMETHEE and ELECTRE can be applied, comparatively in a fuzzy environment and the results can be compared. Acknowledgment: The author would like to thank anonymous referees for their valuable input and suggestions.

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