The Effects of Weight Criteria in Multi-Criteria Decision Making Methods

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Abstract: ***Multi criteria decision making (MCDM) is one of the most important field in expert system and research operation. The methods of MCDM required a weight for the decision criteria to produce the final rank for the alternatives. Two main ways to compute the weight for the criteria subjective and objective ways. In this paper, present the effect between the subjective and the objective to compute the weight for the decision criteria on the final rank for alternatives.***

Keywords: MCDM, TOPSIS, Entropy, Weight

1. Introduction

Multi criteria decision making (MCDM) is one of growing field in operation research and management. The main idea of MCDM is to determine the best alternative from a set of alternatives depend on multiple criteria[1]. In general, the MCDM methods can classified into two approaches mathematical approach and human approach. In mathematical approach the methods used sequence of mathematical operations to produce the final rank for alternatives such as Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) [2], VIseKriterijumskaOptimizacija I KompromisnoResenje (VIKOR) [3], etc.

For human approach the methods involve human preferences to produce the final rank such as Analytic Hierarchy Process (AHP) [4], Best-Worst Method (BWM) [5], and etc.

TOPSIS is one of the most methods used in MCDM, the main idea of TOPSIS is compute the distance between the positive ideal solution (PIS) and negative ideal solution (NIS) with each alternative. The alternative closest to PIS and farther from NIS in same time this the best alternative [6]. The steps of TOPSIS as follow[3]:

Step 1: Create a decision matrix consisting of m alternatives and n criteria.

Step 2: normalized the decision matrix by using

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{k=1}^{m} x_{kj}^2}} \quad (1)$$

Step 3: weighted the normalized matrix by using

$$v_{ij} = w_i * r_{ij} \quad (2)$$

Where w_i is the weight of ith attribute or criterion.

$$\sum_{i=1}^{n} w_i = 1 \quad (3)$$

Step 4: Determine the positive and negative-ideal solution. by using

$$A^* = \{v_1^* \dots \dots v_n^*\}$$

$$A^* = \{(\max_j v_{ij} \mid i \in I'), (\min_j v_{ij} \mid i \in I'')\} \quad (4)$$

$$A^- = \{v_1^* \dots \dots v_n^*\}$$

$$A^- = \{\left(\min_j v_{ij} \mid i \in I'\right), \left(\max_j v_{ij} \mid i \in I''\right)\} \quad (5)$$

where I' is associated with benefit criteria, and I'' is associated with cost criteria.

Step 5: Calculate the separation measures, using Euclidean distance. The separation of each alternative from the PIS is given as

$$D_j^* = \sqrt{\sum_{i=1}^{n} (v_{ij} - v_i^*)^2}, j = 1, \dots, J \quad (6)$$

The distance from the NIS is given as

$$D_j^- = \sqrt{\sum_{i=1}^{n} (v_{ij} - v_i^-)^2}, j = 1, \dots, J \quad (7)$$

Step 6: Calculate the relative closeness to the ideal solution. The relative closeness of the alternative a_j with respect to A^* is defined as

$$C_j^* = \frac{D_j^-}{D_j^* + D_j^-}, \quad j = 1, \dots, J \quad (8)$$

Step 7: Rank the preference order.

The weight of criteria is one of most and compulsory steps. In general, MCDM methods have two ways to compute the weight for the criteria. The first way by using one of human approach methods to compute the weight for criteria. The second way by using objective weight such as entropy to compute the weight from the decision matrix and without used another method from human approach.

One of the most important challenges in decision-making methods is the weight, where weight affects the ranking directly, and the weight is affected by the opinion of the decision-makers. Each decision maker has his own opinion in evaluating the criteria and therefore there will be an impact on the results [7-21]

In this paper we make a comparative between the subjective weight and the objective weight and present the effect on the final rank.

2. Entropy Method

The entropy is one of the most methods used to compute the objective weight. The steps of entropy as following:

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Step One: From the decision matrix, calculate the normalization matrix (P) according the Eq. below

$$P_{ij}=X_{ij}/\sum(X_{ij}) \quad (9)$$

Step 2: Calculate the Entropy value (ej) by the Eq. blow, in the following steps:

$$e_j=-\frac{1}{\ln(m)}\sum_{i=1}^{m}p_{ij}\ln(p_{ij}),\quad i\in[1,m], j\in[1,n] \quad (10)$$

Step 3: Find the degree of diversity (dj) by subtraction the entropy value of the vector above from 1

$$d_j=1-e_j \quad (11)$$

Step 4: The final step is find first the summation of the dj vector above. To compute the weight of each criterion.

3. Case study

In this paper, the case study is networking field. [35] presented improvement of SCTP congestion control. The authors of this case study used MCDM to select best protocol depend on four criteria (i.e. the number of packets received queue size, the number of packets lost, congestion control window (CWND)). The value of N from 1 to 9 were represented the alternatives of this case study. The decision matrix as reported in Table 1.

Table 1: Decision Matrix

Alternative	*CWND*	*Throughput*	*Queue size*	*Pkt loss*
1	120	9,881,687	48,424.92	209.75
2	130	9,912,326	56,199.3	81.75
3	145	9,905,462	53,788.4	24
4	200	10,120,778	51,274.2	27
5	205	9,902,374	51,274.2	43.5
6	212	10,023,750	51,180.7	64.5
7	202	10,264,182	57,581. 3	70.5
8	225	10,106,678	52,895.4	94.5
9	235	10,368,886	59,680. 9	104

The authors of this case study distribute the weight between the criteria equally. For each criterion give 0.25 weight. So, in this research, we applied the entropy method to compute the objective weight for each criterion. Then, we applied TOPSIS to make the rank and present the differences in rank between the two ways if happen. The equations of entropy method applied on Table 1, and the weight of each criterion as following Table 2:

Table 2: The weight of each criterion

CWND	*Throughput*	*Queue size*	*Pkt loss*
0.111670049	0.000609461	0.008993346	0.878727

After extract the weight for each criterion, know applied TOPSIS to produce the rank for the alternatives. The rank of alternatives reported in Table 3.

Table 3: The rank for alternatives

Alternatives	*Score*	*Rank*
1	0.038146	9
2	0.68938	6
3	0.991444	1
4	0.968539	2
5	0.891449	3
6	0.780184	4
7	0.748493	5
8	0.619395	7
9	0.568278	8

The best alternative by using TOPSIS with objective weight is 3 as a best solution. In the case study the authors find alternative 4 is the best solution. That mean, the way of compute the weight for the decision criteria is effect on the final results.

4. Conclusion

Different ways to compute the weight for the decision criteria in multi criteria decision making. the subjective way, when used the preference of the human to extract the weight for the decision criteria. And, the objective way, by used a mathematical operation to compute the weight for the decision criteria for the decision matrix. the entropy method that used in this research to compute the weight is effect on final decision. In future work, apply different objective ways and compare with subjective way, to extract the difference.

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