Hub location selection decision with a hybrid method of Fuzzy Dematel Analytical Network Process and Fuzzy VIKOR.

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Abstract: Necessity of selecting the best hub location considering saving time, raising the satisfaction level is not negligible in each transportation system. Making the selection criteria closer to natural language will lead to much more easy and reliable solutions. In this paper we use a proposed hybrid method to get advantages of linguistic variables with an efficient decision making method. Some numerical examples are generated randomly to verify efficiency of the proposed solution approach. In the proposed method not only the best hub location is chosen, but also it gives a ranking list. Here we consider constructing a hypothesized new metro line in Tehran subway system, which connects the northwest of Tehran to southeast of the city, and seven alternatives have been selected to be compared.

Keywords: Linguistic variables, Analytical Network Process, L-DANP, L-VIKOR, Fuzzy numbers.

1. INTRODUCTION

The use of linguistic variables increases the computational time but accessing to decision maker preferences via these variables is simple and easy because of their tangibility for the DM. Thus, this study proposes a new crossbred MADM model combining the DEMATEL-based Analytic Network Process for linguistic variables (L-DANP) to find the influential weights, and VIKOR by linguistic ones (L-VIKOR) method to calculate performance by applying FUZZY sets. This approach not only focuses on ranking and selecting from a set of alternatives in cases of conflicting criteria but also on diagnosing and improving policies to reduce gaps in each criteria to promote satisfaction level of customers' needs.

This paper has been organized as following: In the next section a literature review is presented then the proposed method is illustrated in section 3. The results and analysis of the selected case study are reported in section 4 and finally the conclusion will be mentioned in the last section.

2. LITERATURE REVIEW

Increased production economies of scale and reduced transportation cost have focused attention on hubs. In process of selection it is essential first to recognize the influential factors relevant to location selection criteria. Chen-Tung Chen[1] introduced a method which used a fuzzy approach based on preference relation matrix. Shuo-Yan Chou[2] by applying linguistic variables and fuzzy sets in SAW, introduced FSAW to calculate the importance weight. Another related method was proposed by Liang and Wang[3] which DM uses linguistic terms to weight criterion. In classical model assumes that the criteria are independent; however the relationships between criteria are usually interdependent in the real-world problem. In these studies this relationship have not been mentioned. This paper focuses on ''ranking'', ''selection'' and "identifing weaknesses" of alternatives, besides gathering influential weights considering this relationship.

3. PROPOSED METHOD

The proposed hybrid method has main two parts of L-DANP and L-VIKOR, while in the first part the criteria weights are determined and in the second part the performance gap for each alternative is calculated.

3.1. L-DANP part of the proposed algorithm

In classical ANP it is assumed that criteria have the same weights, but it is not accurate. The DANP influential weights can overcome this weakness. Therefore, the criteria influence should be asked from experts with following clauses: "no influence", "low influence", "medium influence", "high influence" and "very high influence". Here, we use following Triangular Fuzzy Sets for mentioned clauses respectively: [0 0.4 0.8], [0.8 1.2 1.6], [1.6 2 2.4], [2.4 2.8 3.2],[3.2 3.6 4].

To get the Fuzzy weights of selected criteria we apply DANP method for lower, middle and the upper sides of sets according to following steps based on the proposed approach of Wan-Yu Chiu[4]:

1) Gather the direct influential matrix (G).
2) Normalize direct influential matrix (X).
3) Calculate total-influential matrix T_c by $x(x-I)^{-1}$.

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4) Normalize total-influential matrix T_D^{nor} .

5) Normalize matrix T_c^{nor} by dimensions and clusters.

6) Compute the un-weighted super-matrix.

7) Calculate final weights by $\lim_{\phi\to\infty}\left(W_c^*\right)^{\phi}$.

3.2. L-VIKOR part of the proposed algorithm

This part includes the succeeding stages:

1) Set the fuzzy set for each alternative in each criterion.

2) Set positive ideals solution (f_i^*) and negative one (f_i^-) for each criterion.

3) Compute the performance gap for each alternative in each criterion using "(1)"

$$gap_{ij} = w_i * (f_i^* - f_{ij}) \big/ (f_i^* - f_i^-) \qquad (1).$$

The difference value of two fuzzy numbers of $f_1 = [a_1, b_1, c_1], f_2 = [a_2, b_2, c_2]$ can be computed by "(2)"

$$D(f_1, f_2) = \sqrt{1/3\left((a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)\right)} \qquad (2).$$

Stage 4) Compute the total gap for each alternative using "(3)".

$$s_j = \sum_j gap_{ij} \qquad (3).$$

The best alternative as the hub node can be selected according to the minimum value of computed total gap.

4. A case study: Selecting the best Hub in Tehran sub way

Before starting up the new line, Metro Organization of Tehran needs to choose the best candidate stations as Hubs. The first cluster of Criteria includes car and human traffic, second one includes air pollution, third one includes safety, availability and enough space, and the last includes setup, transportation and time saving.

According to metro map, 8 stations of Azadi, Enqelab Sq., Valiasr, Imam Ali University, Imam Khomeini, Darvazeh Dolat, and Darvazeh Shemiran, are candidate stations to be as a new hub node. By using the proposed hybrid method, first of all a 9 *9 influential matrix (G) of selected criteria were gathered. Small part of mentioned matrix has been reported in Table 1

Table 1. Small part of the influential matrix in the case study

	a1	a2	b1
a1) Car traffic	No influence	Medium influence	Medium influence
a2)Human traffic	Medium influence	No influence	High influence

By applying the L-DANP, and calculating the fuzzy weights, their values will be resulted as

Table 2. In the next step fuzzy weights have been converted to crisp numbers by Center Of Area approach as reported in the last row of

Table 2.

Table 2. The weights of selected criteria in the case study

	a1	a2	b1	c1	c2	c3	d1	d2	d3
W^l	0.117	0.117	0.115	0.121	0.12	0.094	0.109	0.117	0.086
W^m	0.116	0.116	0.115	0.119	0.118	0.097	0.11	0.115	0.092
W^u	0.114	0.115	0.114	0.117	0.116	0.099	0.11	0.115	0.096
W	0.1157	0.116	0.1147	0.119	0.118	0.0962	0.1097	0.115	0.091

Then the linguistic information about the performance of each station in each criterion has been gathered and their crisp values have been calculated which their values for two stations of 1 and 8 have been reported in Table 3. Finally the total performance gap of each station has been computed.

Table 3. The performance gap of stations 1 & 8 in each criterion

	a1	**a2**	**b1**	**c1**
S1 Performance GAP	0.202448	0.202448	0	0.202448
…	….	….	….	….
S8 Performance GAP	0.202448	0	0.387883	0.541622

The calculated total gap of each station can be reported as :{Azadi: 0.34, Darvazeh dolat: 0.38, Darvazeh shemiran: 0.4, Enqelab Sq: 0.18, Imam Ali Uni.: 0.3, Imam Khomeini: 0.06, Valiasr: 0.24}. By considering of total performance gap the stations of Imam Khomeini and Enqelab Sq. with lowest gaps can be selected as hub stations of the new Tehran metro line.

5. Conclusion

In this paper a proposed hybrid method of L-DANP and L-VIKOR is presented to select more preferable location to be a hub node while the first part focuses to calculate the criteria weights and the second part evaluate the potential alternatives. The analysis of the proposed method in the metro line case study shows its applicability in real cases. In the selected case study 9 criteria were selected while there were 8 potential stations to be as the new line hub. Finally two stations with lowest performance gap were selected as the new metro line hub in which contain better values in all criteria comparing to others. Considering of other hub location aspects such as allocation cost and etc. can be as a future research.

6. REFRENCES

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