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TOPSIS Method for Supplier Selection Problem

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***Abstract*—**Supplier selection, in real situation, is affected by several qualitative and quantitative factors and is one of the most important activities of purchasing department. Since at the time of evaluating suppliers against the criteria or factors, decision makers (DMS) do not have precise, exact and complete information, supplier selection becomes more difficult. In this case, Grey theory helps us to deal with this problem of uncertainty. Here, we apply Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method to evaluate and select the best supplier by using interval fuzzy numbers. Through this article, we compare TOPSIS with some other approaches and afterward demonstrate that the concept of TOPSIS is very important for ranking and selecting right supplier.

***Keywords*—**TOPSIS, fuzzy number, MADM, Supplier selection

I. Introduction

IN order to maintain a competitive position in the global market, organizations have to follow strategies to achieve shorter lead times, reduced costs and higher quality [1]. Therefore, suppliers play a key role in achieving corporate competitiveness, and as a result of this, selecting the right suppliers is a critical component of these new strategies [1].

Several conflicting quantitative and qualitative factors or criteria like cost, quality, delivery etc. affect supplier selection problem; therefore, it is a Multi-Attribute Decision Making (MADM) problem. Several methods, such as the analytic hierarchy process (AHP) [2,3], the analytic network process (ANP) [4], the linear weighting methods (LW) [5,6], total cost approach (TCA) [7,8] and mathematical programming (MP) techniques [9,10], have helped decision makers (DMs) to deal with supplier selection problem. However, the problem of selecting suppliers is that most of the input information is not known precisely [1,11]. That is why, the problem becomes more difficult and complicated [11]. In these cases, the fuzzy sets theory is usually used for dealing with uncertainty. However, the disadvantage of fuzzy sets theory is that it cannot handle incomplete data and information [11].

To overcome the problem, Deng in 1989 [12] proposed Grey theory being an effective mathematical tools to deal with systems analysis characterized by imprecise and incomplete information [11]. So, the advantage of grey theory over fuzzy theory [13,14] is that grey theory, in addition to the condition of the fuzziness, can take incomplete data and information into consideration [11,12]. Grey theory is based on the degree of information known [11,12]: if the system information is unknown, it is called a black system; if the information is fully known, it is called a white system; and eventually, if the information is known partially, it is called a grey system.

In grey theory, there are two famous methods proposed by Deng [12] and Li et al. [11]. The two methods are used for MADM problems; evaluating and ranking alternatives against some factors or criteria. The methods are similar to TOPSIS method. Deng's [12] method is based on the minimization of maximum distance from the ideal referential alternative. Zhang et al. [15] presented the method of Deng [12] as a means to reflect uncertainty in multiple attribute models through interval fuzzy numbers.

Li's et al. [11] grey based approach, applied for supplier selection problem, calculates a grey possibility degree between compared suppliers alternatives set and ideal referential supplier alternative to determine the ranking order of all alternatives of supplier and to select the ideal supplier based on grey numbers.

Although the two methods [11,12] are similar to TOPSIS, they neglect the negative ideal referential alternative to evaluate and rank the alternatives. Based on TOPSIS or the concept of TOPSIS the chosen alternative should have the shortest distance from the positive ideal solution (PIS) and the farthest from the negative ideal solution (NIS) [16]. According to Shaniana and Savadogo [17] considering both positive and negative ideal solution for evaluating alternatives is necessary. For tackling the problem of Li's et al and Deng's, Jadidi et al. [18] proposed a new technique by using TOPSIS concept. In fact, the authors improved the methods of Li et al. [11] and Deng [12] by this concept. In the article, Jadidi et al. [18] compared his method with the methods of Li et al. and Deng and demonstrated that the new method based on TOPSIS concept has a more optimal solution.

In this article, instead of using TOPSIS concept, we use TOPSIS method itself to evaluate and select the best supplier in grey theory. The relative closeness between each of the alternative sequence and the referential sequences (positive and negative ideal solutions) is calculated to compare the ranking of grey numbers and select the most desirable supplier. In order to be capable of comparing the result of TOPSIS with the result of Deng's [12], Li's et al. [11] and Jadidi's et al. [18] methods, similar to Jadidi et al. [18], we use Li's et al. [11] article assumption, data and information. Through this article, we also show that TOPSIS concept is necessary to be utilized for solving the MADM problems such as evaluating and selecting the best supplier. We organize the remainder of this paper as follows. Section 2 introduces the

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TOPSIS method for the problem. Then, in Section 3, an illustrative example presents applying TOPSIS for the supplier selection problem and comparing its result with Deng's, Li's et al. and Jadidi's et al.. Eventually, Section 4 presents conclusions.

II. TOPSIS APPROACH

By TOPSIS, developed by Hwang and Yoon [16] for evaluating and ranking alternatives against some factors, the chosen alternative has the shortest distance from PIS and the farthest from NIS.

In order to apply TOPSIS for evaluating suppliers we use Li's et al. [11] article assumption, data, information, and notations (see [11,18]). k is number of DMs; S_i, i=1,2,…,m, is number of suppliers; Q_j, j=1,2,…,n, is number of criteria or attributes of suppliers; W_j is the criteria weights.

The first five steps of TOPSIS for solving the supplier selection problem is the same as Li's et al. [11] (see also [18]). Hence, we neglect to explain these five steps in detail, but the last four steps are completely described.

The steps are:

Step 1
By a committee of DMs, the attribute weight of attribute Q_j is obtained.

Step 2
By the committee of DMs, the attribute rating value is obtained.

Step 3
The grey decision matrix is constructed.

Step 4
The normalized grey decision matrix is constructed.

Step 5
The weighted normalized grey decision matrix is constructed.

Step 6
As a referential alternative, make the ideal, $S^{\max}=\{G_1^{\max},G_2^{\max},...,G_n^{\max}\}$, and negative-ideal, $S^{\min}=\{G_1^{\min},G_2^{\min},...,G_n^{\min}\}$, alternatives, which can be obtained in Eqs. (1)-(2), respectively.

$$S^{\max}=\{[\max_{1\le i\le m}\underline{G_{i1}},\max_{1\le i\le m}\overline{G_{i1}}],...,[\max_{1\le i\le m}\underline{G_{in}},\max_{1\le i\le m}\overline{G_{in}}]\} \quad (1)$$

$$S^{\min}=\{[\min_{1\le i\le m}\underline{G_{i1}},\min_{1\le i\le m}\overline{G_{i1}}],...,[\min_{1\le i\le m}\underline{G_{in}},\min_{1\le i\le m}\overline{G_{in}}]\} \quad (2)$$

Step 7
If S_i^+ is the distance of each alternative from the PIS and S_i^- is the distance from the NIS, use Eqs. (3)-(4) to calculate the separation of each alternative from the ideal solution and negative ideal solution, respectively:

$$S_i^+=\sum_{j=1}^{n}\left|V_{ij}-G_i^{\max}\right| \quad (3)$$

$$S_i^-=\sum_{j=1}^{n}\left|V_{ij}-G_i^{\min}\right| \quad (4)$$

where $i=1,…,m$.

Step 8
The relative closeness to the ideal solution is calculated in Eq. (5).

$$C_i^*=\frac{S_i^-}{S_i^++S_i^-}\, i=1,...,m \quad (5)$$

where $0\le C_i^*\le 1$.

Step 9
Rank the order of suppliers, so that when C_i is bigger, the ranking order of S_i is better.

III. APPLICATION AND ANALYSIS

Four DMs, D_1, D_2, D_3 and D_4, are going to evaluate six suppliers as alternatives against product quality Q_1, service quality Q_2, delivery time Q_3 and price Q_4. Where Q_1, Q_2 and Q_3 are benefit attributes, and Q_4 is cost attribute. Note again that the first five steps of the method are described the same as Li's et al. [11] method, and the results related to these five steps can be seen in Jadidi's et al. [18] and/or Li's et al. [11] articles. Here, we briefly describe the first five steps, while we go in detail for the last four steps.

The procedure is shown as follows:

Step 1
The values of four attributes' weights by four DMs are calculated.

Step 2
The attribute rating values for six supplier are calculated.

Step 3
The grey decision matrix is then established.

Step 4
The grey normalized decision table is constructed.

Step 5
The grey weighted normalized decision is established.

Step 6
According to Eqs. (1)-(2) make the ideal $S^{\max}$ and negative ideal $S^{\min}$ suppliers as a referential alternatives, which are shown as follows:

$$S^{\max}=\{[0.470,0.925],[0.550,0.950],[0.383,0.750],[0.350,0.550]\}$$
$$S^{\min}=\{[0.368,0.617],[0.200,0.443],[0.283,0.477],[0.249,0.385]\}$$

Step 7

According to Eqs. (3)-(4) calculate the separation of each supplier from the ideal and negative ideal supplier, which are shown as follows:

$$S_1^+ = 0.12 \quad S_2^+ = 0.26 \quad S_3^+ = 0.86$$
$$S_4^+ = 0.95 \quad S_5^+ = 1.03 \quad S_6^+ = 1.11$$

$$S_1^- = 1.16 \quad S_2^- = 1.01 \quad S_3^- = 0.39$$
$$S_4^- = 0.32 \quad S_5^- = 0.24 \quad S_6^- = 0.14$$

Step 8

According to Eq. (5) calculate the relative closeness of each supplier to the ideal supplier, which are shown as follows:

$$C_1^* = 0.904 \quad C_2^* = 0.795 \quad C_3^* = 0.313$$
$$C_4^* = 0.254 \quad C_5^* = 0.187 \quad C_6^* = 0.112$$

Step 9

According to the relative closeness of each supplier to the ideal supplier calculated in *step* 8, the result of ranking order is shown as follows:

$$S_1 > S_2 > S_3 > S_4 > S_5 > S_6$$

By going to the article of Jadidi et al. [18], which compared his method with Li's et al. [11] and Deng's [12], the results of the three methods for the same problem are as follows:

The result of Li's et al. [11] method [11,18]:

$$P_1 = 0.539 \quad P_2 = 0.575 \quad P_3 = 0.789$$
$$P_4 = 0.747 \quad P_5 = 0.771 \quad P_6 = 0.840$$

The smaller one is better.

$$S_1 > S_2 > S_4 > S_5 > S_3 > S_6$$

The result of Deng's [12] method [18]:

$$C_1 = 0.054 \quad C_2 = 0.098 \quad C_3 = 0.283$$
$$C_4 = 0.277 \quad C_5 = 0.298 \quad C_6 = 0.336$$

The smaller one is better.

$$S_1 > S_2 > S_4 > S_3 > S_5 > S_6$$

The result of Jadidi's et al. [18] method:

$$\Gamma_1 = 0.0325 \quad \Gamma_2 = 0.0665 \quad \Gamma_3 = 0.1725$$
$$\Gamma_4 = 0.1827 \quad \Gamma_5 = 0.1959 \quad \Gamma_6 = 0.2171$$

The smaller one is better.

$$S_1 > S_2 > S_3 > S_4 > S_5 > S_6$$

Suppliers 1 and 2 are the first and second, respectively, in the all methods, but supplier 3 is fifth in Li's et al. [11] method, fourth in Deng's [12] method and third in TOPSIS and Jadidi's et al. [18] method. Jadidi et al. [18] showed that his result is better than Li's and Deng's. In addition, the results of TOPSIS and Jadidi's are very close to each other.

In this case, if the company needs to allocate order quantities to more than one supplier, for example 3 suppliers, definitely the company should not have an optimal assignment if he uses Li's and Deng's. Here, we, similar to Jadidi et al. [18], demonstrated that TOPSIS or its concept is very important for having a right evaluation and selection.

IV. Conclusion

In this paper, we used TOPSIS method for the same problem of Li's et al. [11] article (supplier selection problem). Then we compared the result of TOPSIS with the results of other three methods, Deng [12], Li et al. [11] and Jadidi et al. [18], to show that TOPSIS concept in evaluating alternatives makes better result.

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