An Appli**cation of TOPSIS Method in Supplier Selection Problems with Target Values**

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Abstract

Decision makers always consider many criteria in supplier selection problems to find out their best suppliers. Hence, the supplier selection problem belongs to the multiple criteria decision making (MCDM) problem. There are many approaches to solve the MCDM problem, the technique for order preference by similarity to ideal solution (TOPSIS) is one of often used methods. The study used the TOPSIS method and extended the method in supplier selection problems when decision makers set the target value of each criterion. After case testing, the proposed method and procedure can help the managers select the proper supplier in supply chain according to their target values in different criteria.

Keywords：TOPSIS Method, Target Value, Supplier Selection, MCDM

1. Introduction

It is an important job for decision makers to select proper suppliers in their supplier chain systems. They need to use some criteria to evaluate their alternatives and find out which one is the best for them. Hence, the supplier selection problem belongs to the multiple criteria decision making (MCDM) problem (Liao, 2008).

Weber, Current and Benton (1990), Tam and Tummala (2001) and Liao (2008) paid their attention to survey how to select criteria in this problem, such like "the product quality offering price, delivery lead time, service satisfaction, warranty degree, experience and financial stability" (Liao, 2008).

Zeleny (1982) discussed the concept of an ideal solution in MCDM problems. Hwang and Yoon (1981) proposed the technique for order preference by similarity to ideal solution (TOPSIS) to consider the distance from the ideal solution. Saaty (1980) proposed the analytic hierarchy process (AHP) method by using top-down and bottom-up approaches to find out solutions. They proposed different kinds of approaches to solve the MCDM problem.

Hence, Tam and Tummala (2001) used the AHP method to select suppliers. Liao (2008) used Taguchi loss function, AHP and multi-choice goal programming (MCGP) to select right suppliers. Fu (2009) used the TOPSIS method to solve the problem.

Although the TOPSIS method is useful to solve MCDM problems, its approach only considers the maximal or minimal value of each criterion. However, decision makers often set the target value of each criterion in their decision process. The target value of a criterion may be not in maximal or minimal value of the criterion. Hence, the study extended the TOPSIS

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method to solve the supplier selection problems with target values.

2. The Proposed Method and Procedure

The basic concept of the TOPSIS method is to find out the maximal (minimal) value of all alternatives at each criterion to be its positive (negative) ideal solution when the criterion belongs to the effectiveness (cost) set. The paper extended the concept as below.

Definition 1: Let x_{ij} be the performance value of alternative A_i at the criterion C_j.

Definition 2: Let t_{C_j} be the target value of the criterion C_j. Let S_E, S_C and S_T denote the effectiveness, cost and target sets, respectively. The target value is given by the decision makers as below.

$$t_{C_j}\begin{cases} \geq \max_i\{x_{ij}\}, & if \quad C_j \in S_E, \\ \in (\min_i\{x_{ij}\}, \max_i\{x_{ij}\}), & if \quad C_j \in S_T, \\ \leq \min_i\{x_{ij}\}], & if \quad C_j \in S_C. \end{cases} \tag{1}$$

Definition 3: If C_j belongs to the set of target S_T, decision makers need to set the values of lower bound t_{LB_j} and upper bound t_{UB_j} of C_j and its relations between both sides of the target value t_{C_j}, the smaller/less is better or the larger/more is better as below in equation (2).

$$p(x_{ij}) = \begin{cases} 0, & if \quad x_{ij} < t_{LB_j}, \\ \left(\dfrac{x_{ij} - t_{LB_j}}{t_{C_j} - t_{LB_j}}\right)^{\alpha} & if \quad t_{LB_j} \leq x_{ij} < t_{C_j}, \\ 1, & if \quad x_{ij} = t_{C_j}, \\ \left(\dfrac{t_{UB_j} - x_{ij}}{t_{UB_j} - t_{C_j}}\right)^{\frac{1}{\alpha}} & if \quad t_{C_j} < x_{ij} \leq t_{UB_j}, \\ 0, & if \quad x_{ij} > t_{UB_j}. \end{cases} \tag{2}$$

Where $t_{LB_j} \leq \min_i\{x_{ij}\} < t_{C_j} < \max_i\{x_{ij}\} \leq t_{UB_j}$ and α is the adjustable factor. If smaller/less (larger/more) is better, then $0 < \alpha < 1$, otherwise $\alpha > 1$.

Definition 4: Let x'_{ij} and t'_{C_j} be defined in equations (3) and (4), respectively.

$$x_{ij}^{'}=\begin{cases} x_{ij}, & if \quad C_j \in \{S_E, S_C\}, \\ p(x_{ij}), & if \quad C_j \in S_T. \end{cases}, i \in \mathbb{I}=\{1,2,\Lambda\ ,m\},\ j \in \mathbb{J}=\{1,2,\Lambda\ ,n\}. \tag{3}$$

$$t_{C_j}^{'}=\begin{cases} t_{C_j}, & if \quad C_j \in \{S_E, S_C\}, \\ 1, & if \quad C_j \in S_T. \end{cases}, i \in \mathbb{I},\ j \in \mathbb{J}. \tag{4}$$

Definition 5: The normalized values of $x_{ij}^{'}$ and $t_{C_j}^{'}$ are denoted as n_{ij} and $n_{t_{C_j}}$, and defined in equation (5), respectively.

$$n_{ij}=\frac{x_{ij}^{'}}{\sqrt{\sum_{i=1}^{m}(x_{ij}^{'})^2}},\quad n_{t_{C_j}}=\frac{t_{C_j}^{'}}{\sqrt{\sum_{i=1}^{m}(x_{ij}^{'})^2}}, i \in \mathbb{I},\ j \in \mathbb{J}. \tag{5}$$

Definition 6: The weighted values of n_{ij} and $n_{t_{C_j}}$ are denoted as v_{ij} and v_{C_j}, and defined in equation (6), respectively.

$$v_{ij}=n_{ij}\cdot w_j,\quad v_{C_j}=n_{t_{C_j}}\cdot w_j, i \in \mathbb{I},\ j \in \mathbb{J}. \tag{6}$$

Where $0 \le w_j \le 1$ and $\sum_{j=1}^{n} w_j = 1$.

Definition 7: Let I^* be the positive-ideal solution of all alternatives.

$$I^*=\{v_1^*, v_2^*, \Lambda\ , v_n^*\}=\{(v_{C_j} \mid C_j \in \{S_E, S_C, S_T\})\}, i \in \mathbb{I},\ j \in \mathbb{J}. \tag{7}$$

Definition 8: Let I^- be the negative-ideal solution of all alternatives.

$$I^-=\{v_1^-, v_2^-, \Lambda\ , v_n^-\}=\{(\min_i v_{ij} \mid C_j \in \{S_E, S_T\}), (\max_i v_{ij} \mid C_j \in S_C)\}, i \in \mathbb{I},\ j \in \mathbb{J}. \tag{8}$$

Definition 9: Let S_i^* be the distance between alternative A_i and the positive-ideal solution.

$$S_i^*=\sqrt{\sum_{j=1}^{n}(v_{ij}-v_j^*)^2}, i \in \mathbb{I}. \tag{9}$$

Definition10: Let S_i^- be the distance between alternative A_i and the negative-ideal solution.

$$S_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2}\ , i \in \mathbb{I}. \tag{10}$$

Definition11: The preference value C_i^* of the alternative A_i is defined in equation (11).

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^+}\ , i \in \mathbb{I}. \tag{11}$$

The procedure of the TOPSIS method in supplier selection problems with target values is listed as below.

Step 1: Calculate the value $x_{ij}^{'}$ and $t_{C_j}^{'}$ by equations (2)-(4) , $i \in \mathbb{I}$, $j \in \mathbb{J}$.

Step 2: Calculate the normalized value n_{ij} and $n_{t_{C_j}}$ by equation (5), $i \in \mathbb{I}$, $j \in \mathbb{J}$.

Step 3: Calculate the weighted normalized value v_{ij} and v_{C_j} by equation (6), $i \in \mathbb{I}$, $j \in \mathbb{J}$.

Step 4: Find out the positive-ideal solution I^* and negative-ideal solution I^- by equations (7) and (8).

Step 5: Calculate the distance from the positive-ideal solution of each alternative, S_i^* by equation (9), and the distance from the negative-ideal solution of each alternative, S_i^- by equation (10).

Step 6: Calculate the C_i^* by equation (11). Arrange alternatives and make choice, the larger/more is better.

3. A Numerical Example

There are five alternative suppliers, named A, B, C, D and E. The decision maker decides to consider seven criteria, “defective rate”, “price”, “delivery time”, “service satisfaction”, “warranty degree”, “experience time” and “financial stability”, to evaluate and select one supplier. The data are listed in
Table **1**.

The first three criteria belong to the set of S_C , the less/lower is the better. The last one belongs to the set of S_T , its target value is 900, its lower bound is 500, and its upper bound is 1500 and the smaller/less is better, $\alpha = .5$. The others belong to the set of S_E , the larger/more is the better. The study used the entropy method (Hwang and Yoon,1981; Zeleny,1982) to calculate the weight data of each attribute listed in Table3.

Hence, the study calculated the results step by step as below.Steps 1 and 2: Calculate the normalized value in Table2.

Step 3: Calculate the weighted normalized value in Table4.

Step 4: Find out the positive-ideal solution I^* and negative-ideal solution I^- in Table4.

Step5:Calculate the distances from the positive-ideal solution S_i^* and the negative-ideal solution S_i^- of each alternative in Table5.

Step 6: Arrange alternatives in Table5

Table 1 The data of suppliers

Item	Defective rate (%)	Price ($)	Delivery time (day)	Service satisfaction (%)	Warranty degree (%)	Experience time (year)	Financial stability ($million)
A	1.6	110	1.65	95%	90%	5	700
B	1.8	100	1.85	82%	88%	9	1000
C	1	105	1.6	90%	85%	8	1200
D	1.5	108	1.5	70%	80%	9	1000
E	1.4	115	2	65%	82%	12	600

Table 2 The normalized data

Item	Defective rate	Price	Delivery time	Service satisfaction	Warranty degree	Experience time	Financial stability
A	0.4822	0.4567	0.4267	0.5232	0.4731	0.2516	0.4575
B	0.5425	0.4152	0.4784	0.4516	0.4626	0.4528	0.5392
C	0.3014	0.4359	0.4137	0.4956	0.4468	0.4025	0.3235
D	0.4521	0.4484	0.3879	0.3855	0.4205	0.4528	0.5392
E	0.4219	0.4775	0.5172	0.3580	0.4310	0.6038	0.3235

Table 3 The weight data

Item	Defective rate	Price	Delivery time	Service satisfaction	Warranty degree	Experience time	Financial stability
Weight	0.1720	0.0107	0.0540	0.1011	0.0093	0.3517	0.3011

Table 4 The weighted normalized data and the ideal solutions

Item	Defective rate	Price	Delivery time	Service satisfaction	Warranty degree	Experience time	Financial stability
A	0.0829	0.0049	0.0230	0.0529	0.0044	0.0885	0.1597
B	0.0933	0.0044	0.0258	0.0457	0.0043	0.1593	0.1569
C	0.0518	0.0047	0.0223	0.0501	0.0042	0.1416	0.0565
D	0.0778	0.0048	0.0209	0.0390	0.0039	0.1593	0.1569
E	0.0726	0.0051	0.0279	0.0362	0.0040	0.2124	0.1129
I^*	0.0000	0.0044	0.0070	0.0529	0.0046	0.2124	0.2259
I^-	0.0933	0.0051	0.0279	0.0362	0.0039	0.0885	0.0565

Table 5 The solution of proposed method

	C_i^*	Rank	Choice
A	0.3910	4	
B	0.4881	3	
C	0.2650	5	
D	0.5117	1	ν
E	0.5015	2	

In Table5, the best supplier of decision makers is alternative D which obtained the maximal preference value among all alternatives.

4. Conclusions

The study discussed that how to select the best supplier in supplier selection problems when decision makers set the target value of each criterion. Although many approaches can solve the problem, the study proposed a method and a procedure to extend the TOPSIS method to solve the problem. After numerical example testing, the method and procedure can help decision makers select their best supplier according their target values.

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