A Hybrid Intuitionistic MCDM Model for Supplier Selection

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Abstract: This paper gives an overview of the Analytic Hierarchy Process (AHP) and Intuitionistic Fuzzy TOPSIS (IFT) methods. This study deals an evaluation methodology based on the AHP-IFT where the uncertainty is handeled with linguistic values. First, the supplier selection problem is formulated by AHP is used to determine weights of the criteria. In the second stage, IFT used to obtain full ranking among alternatives based on opinion of the Decision Makers (DMs). The present model provides an accurate and easy classification in supplier attributes by that have been prioritized in the hybrid model. A numerical example is given to clarify the main developed result in this paper.

1 INTRODUCTION

Selection a suitable supplier among different suppliers is an important matter for supply chain management (SCM). Selecting the right suppliers reduces the purchasing cost, quality problems, and long-lead times and definitely improves corporate competitiveness (Vokurka et al., 1998; Humphreys et al., 2007; Rouyendegh and Erkan, 2012). The most important part of the SCM is the purchasing activity, and the multi-criteria analysis appears to be the right solution for the classification of many purchased goods in the firm as the effort to obtain products at a reasonable cost, in the right quantity, the appropriate quality, at the right time from the right source, is quite crucial for a firm's survival at the market (Simchi-Levi et al., 2003). Beside, suppliers have a significant impact on the quality, cost and leadtime of new products and technologies needed to meet new and emerging market demands (Rouyendegh and Erkan, 2012;).

In this study, a hybrid model for supplier evaluation and a selection based on cost, quality, flexibility, delivery, and variety are used in the AHP-IFT hybrid model. The model quantifies five multiple criteria in AHP to combine them into one global variable for decision-making. To do that, we first present the concept of AHP and determine the weight of criteria based on opinion of Decision Makers (DMs). Then, we introduce the concept of IFT and develop model based on opinion of the DMs. A numerical example is also presented to better illustrate the model.

2 BASIC CONCEPT OF IFS

The following, briefly introduce some necessary introductory basic concepts of IFS. IFS A in a finite set R can be written as:

$$\begin{aligned} &A = \{\langle r, \mu_A(r), v_A(r)\rangle \mid r \in R\} \\ &where \\ &\mu_A(r) : \mu_A(r) \in [0,1], R \to [0,1] \\ &v_A(r) : v_A(r) \in [0,1], R \to [0,1] \end{aligned} \tag{1}$$

are membership function and non-membership function, respectively, such that

$$\begin{aligned} &0 \le \mu_A(r) \oplus v_A(r) \le 1 \qquad \forall r \in R \\ &R \to [0,1] \end{aligned} \tag{2}$$

A third parameter of IFS is $\pi_A(r)$, known as the intuitionistic fuzzy index or hesitation degree of whether r belongs to A or not

$$\pi_A(r) = 1 - \mu_A(r) - v_A(r) \tag{3}$$

$\pi_A(r)$ is called the degree of indeterminacy of r to A it is obviously seen that for every $r \in R$:

$$0 \le \pi_A(r) \le 1 \text{ If the } \pi_A(r) \tag{4}$$

It is small, knowledge about r is more certain. If $\pi_A(r)$ is great, knowledge about r is more uncertain. Obviously,

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When $\mu_A(r) = 1 - v_A(r)$ (5)

For all elements of the universe, the ordinary FST concept is recovered (Boran et.al., 2012).
Let A and B are IFSs of the set R, then multiplication operator is defined as follows (Atanassov, 1986).

$$A \otimes B = \{\mu_A(r).\mu_B(r), v_A(r) + v_B(r) - v_A(r).v_B(r) \mid r \in R\} \tag{6}$$

3 AHP- IFT

To rank a set of alternative, the AHP-IFT methodology as outranking relation theory was used to analyze the data of a decision matrix. We assume m alternatives and n decision criteria. Each alternative is evaluated with respect to the n criteria. All the values assigned to the alternatives with respect to each criterion form a decision matrix.

In this study, our model integrates two, well – known models, AHP and IFT methods. The evaluation of the study based on this hybrid methodology given in Figure 1. The procedure for AHP- IFT methodology ranking model has been given as follows:

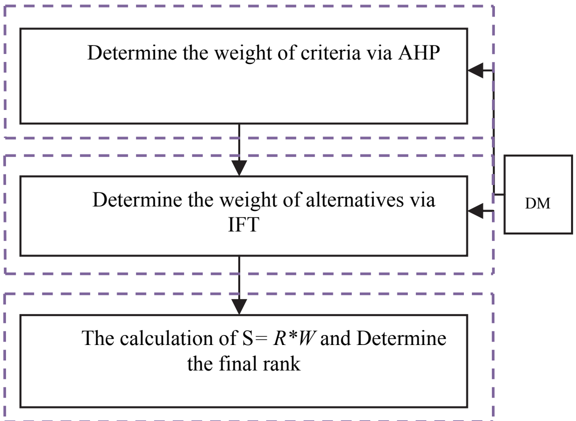

Figure 1: Schematic diagram of the AHP–IFT methodology.

Let A = {$A_1, A_2, \dots, A_m$} be a set of alternatives and C = {$C_1, C_2, \dots, C_n$} be a set of criteria, it should be mentioned here that the presented approach mainly utilizes the IFT method presented in (Boran et.al., 2009; Boran, 2011; Rouyendegh 2012; Shyur, 2006; Xu, 2007d). We modify the selection process to a nine-step, AHP-IFT hybrid procedure, presented as follows:

Step 1. Identify the Alternative

In the first step, we provide a list of projects denoted by A = {$A_1, A_2, \dots, A_m$}

Step 2. Identify the criteria.

The criteria could be denoted by C = {$C_1, C_2, \dots, C_n$}. Identification of criteria, recognition of the relationship between criteria.

Step 3. Determine the weight of criteria based on the opinion of decision makers (Wi).

We assume that decision group contains l = {$l_1, l_2, \dots, l_l$}DMs. The decision group or decision makers are given the task of forming individual pair-wise comparisons by using standard scale of nine levels.

Both distances from each DM can be aggregated as the distances of the group by taking geometric mean:

$$D_i = \left(\underset{j=1}{\overset{k}{\pi}} D_{ij}\right)^{1/k} \qquad i = 1,\dots,m \tag{7}$$

Step 4. Determine the weights of importance of DMs:

In this step, we assume that decision group contains l = { $l_1, l_2, \dots, l_l$} DMs. The importance of the DMs is considered as linguistic terms. These linguistic terms were assigned to IFN. Let $D_l = [\mu_l, v_l, \pi_l]$ be an intuitionistic fuzzy number for rating of kth DM. Then the weight of lth DM can be calculated as:

$$\lambda_l = \frac{\left(\mu_l + \pi_l\left(\frac{\mu_l}{\mu_l + v_l}\right)\right)}{\sum_{l=1}^{k}\left(\mu_l + \pi_l\left(\frac{\mu_l}{\mu_l + v_l}\right)\right)} \tag{8}$$

$$where\ \lambda_l \in [0,1] \quad and \quad \sum_{l=1}^{k} \lambda_l = 1.$$

Step 5. Determine Intuitionistic Fuzzy Decision Matrix (IFDM).

Based on the weight of DMs, the aggregated intuitionistic fuzzy decision matrix (AIFDM) was calculated by applying intuitionistic fuzzy weighted averaging (IFWA) operator (Xu, 2007d). In group decision-making process, all the individual decision opinions need to be fused into a group opinion to construct AIFDM.

Let $R^{(l)} = (r_{ij}^{(l)})_{m \times n}$ is an IFDM of each DM. $\lambda = \{\lambda_1, \lambda_2, \lambda_3, \dots, \lambda_k\}$ is the weight of DM.

$$R = (r_{ij})_{m \times n},$$

Where

$$r_{ij} = IFWA_\lambda(r_{ij}^{(1)}, r_{ij}^{(2)}, \dots, r_{ij}^{(l)}) = \lambda_1 r_{ij}^{(1)} \oplus \lambda_2 r_{ij}^{(2)} \oplus \lambda_3 r_{ij}^{(3)} \oplus \dots \oplus \lambda_k r_{ij}^{(k)} \tag{9}$$

$$=\left[1-\prod_{l=1}^{k}(1-\mu_{ij}^{(l)})^{\lambda_l},\prod_{l=1}^{k}(v_{ij}^{(l)})^{\lambda_l},\prod_{l=1}^{k}(1-\mu_{ij}^{(l)})^{\lambda_l}-\prod_{l=1}^{k}(v_{ij}^{(l)})^{\lambda_l}\right]$$

Step 6. The calculation of S= *R*Wi* :

The weights of criteria (*Wi*) with respect to IFDM (R) is defined as follows:

$$S=R*Wi \tag{10}$$

Step 7. Determine intuitionistic fuzzy positive and negative ideal solution:

In this step, the intuitionistic fuzzy positive ideal solution (IFPIS) and intuitionistic fuzzy negative ideal solution (IFNIS) have to be determined. A^* is IFPIS and A^- is IFNIS. Then A^* and A^- are equal to:

$$A^*=(r_1'^*,r_2'^*,...,r_n'^*),r_j'^*=(\mu_j'^*,v_j'^*,\pi_j'^*),j=1,2,...,n \tag{11}$$

and

$$A^-=(r_1'^-,r_2'^-,...,r_n'^-),r_j'^-=(\mu_j'^-,v_j'^-,\pi_j'^-),j=1,2,...,n \tag{12}$$

Where

$$\mu_j'^*=\left\{(\max_i\{\mu_{ij}'\}\,j\in J_1),(\min_i\{\mu_{ij}'\}\,j\in J_2\right\}, \tag{13}$$

$$v_j'^*=\left\{(\min_i\{v_{ij}'\}\,j\in J_1),(\max_i\{v_{ij}'\}\,j\in J_2\right\}, \tag{14}$$

$$\pi_j'^*=\left\{(1-\max_i\{\mu_{ij}'\}-\min_i\{v_{ij}'\}\,j\in J_1),(1-\min_i\{\mu_{ij}'\}-\max_i\{v_{ij}'\}\,j\in J_2\right\}, \tag{15}$$

$$\mu_j'^-=\left\{(\min_i\{\mu_{ij}'\}\,j\in J_1),(\max_i\{\mu_{ij}'\}\,j\in J_2\right\}, \tag{16}$$

$$v_j'^-=\left\{(\max_i\{v_{ij}'\}\,j\in J_1),(\min_i\{v_{ij}'\}\,j\in J_2\right\}, \tag{17}$$

$$\pi_j'^-=\left\{(1-\min_i\{\mu_{ij}'\}-\max_i\{v_{ij}'\}\,j\in J_1),(1-\max_i\{\mu_{ij}'\}-\min_i\{v_{ij}'\}\,j\in J_2\right\}. \tag{18}$$

Step 8. Determine the separation measures between the alternative:

Separation between alternatives on IFS, distance measures proposed by (Atanassov, 1999) including the generalizations of Hamming distance, Euclidean distance and their normalized distance measures can be used. After selecting the distance measure, the separation measures, S_i^* and S_i^-, of each alternative from IFPIS and IFNIS, are calculated.

$$S_i^*=\frac{1}{2}\sum_{j=1}^{n}\left[\left|\mu_{ij}'-\mu_j'^*\right|+\left|v_{ij}'-v_j'^*\right|+\left|\pi_{ij}'-\pi_j'^*\right|\right] \tag{19}$$

$$S_i^-=\frac{1}{2}\sum_{j=1}^{n}\left[\left|\mu_{ij}'-\mu_j'^-\right|+\left|v_{ij}'-v_j'^-\right|+\left|\pi_{ij}'-\pi_j'^-\right|\right] \tag{20}$$

Step 9. Determine the final ranking

In the final step, the relative closeness coefficient of an alternative is defined as follows:

$$C_i^*=\frac{S_i^-}{S_i^*+S_i^-}\quad where\ 0\le C_i^*\le 1. \tag{21}$$

4 NUMERICAL EXAMPLE

In this section, we will describe how an AHP- IFT hybrid model was applied via an example. Criteria to be considered in the supplier selections are determined by the expert team from a decision group. In our study, we employ five evaluation criteria. The attributes which are considered here in assessment of A_i (i=1,2,3) are: C_1 C_2 ,.., C_5 . The committee evaluates the performance of alternatives A_i (i=1,2,3) according to the attributes C_j (j=1,2,…,5) respectively. After preliminary screening, three alternatives A1, A_2, and A_3, remain for further evaluation. A team of four DMs such as; DM_1, DM_2, and DM_3 has been formed to select the most suitable alternative. Criteria to be considered in the supplier's selection are determined by DMs team from University Procurement Department. There five criteria are as follows: (C1) Cost (C2) Quality (C3) Payment Flexibility (C4) Delivery (C5) Variety.

Now utilize the proposed AHP- IFT hybrid model to prioritize alternatives, the following steps were taken:

After the weights of the criteria and the rating of the alternatives were determined, the aggregated weighted IFD, IFPIS and IFNIS. Negative and positive separation measures based on normalized Euclidean distance for each alternative and the relative closeness coefficient were calculated in Table 1.

Table 1: Separation measures and the relative closeness coefficient of each alternative.

Alternative	S^*	S^-	C_i^*
A1	2.019	2.318	0.533
A2	2.031	2.022	0.467
A3	2.237	2.181	0.494

A numerical example was illustrated the result as follow: Among 3 alternatives with respect to 5 criteria, after using this methodology, the best one is alternative 1 and alternative 3, alternative 2 will follow it respectively.

5 CONCLUSIONS

In this paper, we present a hybrid model using both AHP and intitionistic fuzzy TOPSIS (IFT) models for supplier selection under fuzzy environment to account for vagueness and uncertainty. In the evaluation process, the ratings of each alternative, given with intitionistic fuzzy information, were represented as IFNs. In this hybrid model, AHP is used to assign weights to the criteria, while IFT is employed to calculate the full-ranking of the alternatives. The AHP-IFT hybrid model was used to aggregate the rating of DMs. Multiple DMs are often preferred rather than a single DM to avoid the minimize the partiality in the decision process. Therefore, group decision making process for alternative selection is very useful. The presented approach not only validates the methods, but also considers a more extensive list of criteria, suitable for supplier selection. The AHP-IFT hybrid model has capability to deal with similar types of the same situations.

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