A NEW HYBRID METHODOLOGY FOR SELECTION OF THIRD PARTY LOGISTICS

M. THILAGARAJ * AND M. RAJMOHAN

ABSTRACT

Multicriteria decision making (MCDM) has found many applications in both public and private sector organizations. MCDM is both an approach and a set of techniques, with the goal of providing an overall ordering of options, from the most preferred to the least preferred option. The set of MCDM techniques are implemented in selecting the vendors and 3PL service providers. Supplier selection is a multi-criteria problem which includes both tangible and intangible factors. Proposed approach is based on Fuzzy Analytic Hierarchy Process (FAHP) and MODIFIED REGIME method. FAHP method is used in determining the weights of the criteria by decision makers and then rankings of the firms are determined by MODIFIED REGIME method, we use triangular fuzzy numbers in all pairwise comparison matrices in the FAHP. Hence, criteria weights are calculated as the triangular fuzzy numbers and then these fuzzy criteria weights are inserted to the fuzzy MODIFIED REGIME methodology to rank the alternatives. Proposed method is validated on 3PL vendor selection. The problem is taken from Zhaang, Xiuli (2004), “an application of AHP in 3pl vendor selection of a 4pl system”.

Keywords: FAHP, MODIFIEDREGIME.

1. INTRODUCTION

Logistics has been called the last frontier that even at the present time, the improvement of logistics has been the primary source of firms to make new profits and maintain competitive advantage. There are also several instances where the logistics system has become the cause of bottlenecks in the firm’s overall management. The potential for reducing total cost and for improving the quality of services provided to customers can be increased through the elimination of these bottlenecks. Also, from the social standpoint, an efficient logistics system could offer possibilities to reduce road congestion and environmental pollution, which could result in increased macroscopic economic productivity. Several innovations have been developed to advance the logistics system.

* Corresponding Author: m_thilagaraj@yahoo.co.in

Department of Industrial Engineering, Anna University Chennai, Chennai -600025, India.
These innovations can be classified broadly into innovations to improve individual processes of logistics, and innovations to improve the logistics system totally.

Originally, 3PL means outsourcing logistics activities including transportation and warehousing to outside firms, which are not a consignor or a consignee. However, it is not common 3PL practice to outsource a single activity of logistics independently, but to outsource multiple activities from the firm’s strategic point of view.

3PL (or 3PL provider) has the following features at present:
1. integrated (or multi-modal) logistics service provider
2. contract-based service provider
3. consulting service provider

First, a 3PL provider is regarded as an integrated logistics service provider. IT-related activities for controlling goods flow such as order processing, and inventory management, among others are also included in the function of the 3PL provider. However, the 3PL provider need not provide all the services solely. The 3PL provider can outsource some activities to sub-contractors.

In order to establish reliable partnership, efforts should be made in two stages; 3PL provider selection and contract signing.

First, in the stage of selecting a new 3PL partner, it is important to select the 3PL provider which has the ability to provide better services. If the firms cannot select reliable 3PL providers, they may suffer from economic losses. It is not easy for firms to judge the ability of the 3PL provider during the selection stage owing to the issue of information asymmetry between the firm (principal) and the 3PL provider (agent). To solve this problem, complex selection procedures are necessary to identify their ability. However, the complex selection procedures may involve additional transaction costs.

Second, it is important to establish a system to maintain their reliable partnership once the 3PL partner is selected. Information sharing and apparent risk sharing between the parties is always required. Concerning information sharing, it is needless to say that smoother information exchange will result in a more efficient logistics activity. However, related costs may increase if some information essential to the firm would leak. Therefore, the commitment of each party in information sharing is required, and a scheme to ensure these commitments has to be prepared. However, this would also involve additional transaction costs.

An application of MCDA is used for selecting a new 3Pl partner. MCDA is both an approach and a set of techniques, with the goal of providing an overall ordering of options, from the most preferred to the least preferred option. The purpose is to serve as an aid to thinking and decision making, but not to take the decision. As a set of techniques, MCDA provides different ways of disaggregating a complex problem, of
measuring the extent to which options achieve objectives, of weighting the objectives, and of reassembling the pieces. The main assumption embodied in decision theory is that decision makers wish to be coherent in taking decisions. That is, decision makers would not deliberately set out to take decisions that contradict each other.

Supplier selection is a fundamental issue in the supply chain which heavily contributes to the overall supply chain performance. Supplier selection is the process by which suppliers are reviewed, evaluated and chosen to become part of the company's supply chain. Several factors affect a supplier's performance. The analysis of such criteria and supplier performance measurement has been the focus of many scientists and purchasing practitioners since the 1960s. As an important work, Dickson [1] presented 23 supplier selection metrics. Dickson's paper has been used as a reference for the majority of the papers dealing with the supplier selection problem. Years afterward, Roa and Kiser [2], Ellram [3], Stamm and Golhar [4] identified 60, 18, and 13 criteria for supplier selection, respectively. However, supplier selection is risky and complicated due to uncertainty and conflict between several quantitative and qualitative factors. Organizations have two approaches to supplier selection. The first approach is to select the best single supplier, which can meet all the requirements (single sourcing). The second approach is to select an appropriate combination of suppliers when no single supplier can satisfy all the requirements. Accordingly, management should split order quantities among the available suppliers for a variety of reasons including creating a constant environment of competitiveness (multiple sourcing).

Several methods have been proposed in the literature for single sourcing supplier selection some of which are discussed. One of these methods is data envelopment analysis (DEA), DEA is a mathematical programming (MP) technique that calculates the relative efficiencies (ration of weighted outputs (benefit criteria) to weighted inputs (cost criteria) of multiple decision-making units. Weber and Ellram [5] primarily discussed DEA usage in supplier selection. Also Liu et al. [6], Forker and Mendez [7] and Saen et al. [8] used DEA for rating and choosing the best supplier. Talluri and Narasimhan [9] stated that methods such as DEA have primarily relied on evaluating vendors based on their strengths and failed to incorporate their weaknesses into the selection process. They also added that such approaches would not be able to effectively differentiate between vendors with comparable strengths but significantly different weaknesses.

The analytical hierarchy process (AHP) introduced by Saaty [10], based on pairwise comparison has been applied to supplier selection. Narasimhan [11], Partovi and Banerjee [12], and Lee et al. [13] proposed to use this technique to cope with determining scores. Yigin, I.H., Taskin, H., Cedlmoglu, I.H and Topal, B [14] an expert system (ES) has been designed for selecting suppliers in the supply chain management area. AmyLee, Wen-Chin Chen, Ching-Jan Chang [15], used an analytical approach to select
suppliers under a fuzzy environment. A fuzzy analytic hierarchy process (FAHP) model, which incorporates the benefits, opportunities, costs and risks (BOCR) concept, is constructed to evaluate various aspects of suppliers. Lin and Chen [16], Lee, A.H.I [17], did a comprehensive review of literature and identified 183 decision attributes for evaluating candidate supply chain alliances for general industries. According to the characteristics of triangular fuzzy numbers and the extension principle put forward by Zadeh [18], the operational laws of two triangular fuzzy numbers. Hinloopen, E., Nijkamp, P. and Rietveld, P. [19], used the regime method: a new multi-criteria technique can be viewed as an ordinal generalization of pair wise comparison methods such as concordance analysis. Josefigueira, Salvatoregreco, and Matthisehrgott [20], stated qualiflex as a metric procedure and it is based on the evaluation of all possible rankings (permutations) of alternatives under consideration.

2. HYBRID METHOD FOR 3PL SERVICE PROVIDER SELECTION

The proposed hybrid method has two stages. They are explained in the following sections. They are FUZZYAHP and FINAL RANKING. The step involved in the proposed hybrid framework is shown below:

![Flow Chart for Proposed Method](image-url)
A New Hybrid Methodology for Selection of Third Party Logistics

Proposed method is validated on 3PL vendor selection. The problem is taken from Zhaang, Xiuli (2004), “an application of AHP in 3pl vendor selection of a 4pl system”, IEEE, international conference on systems, man and cybernetics. The hierarchical structure of 3pl vendor selection problem is shown in fig 2. The data is taken from above journal is shown in table 3. and the interval values of fuzzy ratio with respect to each sub criterion are shown in table 1. The sub scores of each supplier with respect to all criteria is shown in table 2.

Fig. 2: 3PL Vendor Selection Problem

Table 1
Interval Values of Fuzzy Ratio with Respect to Each Sub-criterion

<table>
<thead>
<tr>
<th>Fuzzy ratio</th>
<th>LTC</th>
<th>LT</th>
<th>LE</th>
<th>CW</th>
<th>MC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100-200</td>
<td>≥1</td>
<td>≥1</td>
<td>0.01-0.04</td>
<td>≥46</td>
</tr>
<tr>
<td>3</td>
<td>200-300</td>
<td>0.75-1</td>
<td>0.75-1</td>
<td>0.04-0.08</td>
<td>44-46</td>
</tr>
<tr>
<td>5</td>
<td>300-400</td>
<td>0.5-0.75</td>
<td>0.5-0.75</td>
<td>0.08-0.12</td>
<td>42-44</td>
</tr>
<tr>
<td>7</td>
<td>400-500</td>
<td>0.025-0.5</td>
<td>0.025-0.5</td>
<td>0.12-0.16</td>
<td>40-42</td>
</tr>
<tr>
<td>9</td>
<td>≥500</td>
<td>&lt;0.25</td>
<td>&lt;0.25</td>
<td>≥0.16</td>
<td>38-40</td>
</tr>
</tbody>
</table>

Contd...
### Table 2

<table>
<thead>
<tr>
<th>Supplier</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>9</td>
<td>7</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>B</td>
<td>7</td>
<td>3</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>7</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

### Table 3

<table>
<thead>
<tr>
<th>SUB CRITERIA</th>
<th>VENDOR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>LTC</td>
<td>500</td>
</tr>
<tr>
<td>LE</td>
<td>0.8</td>
</tr>
<tr>
<td>MC</td>
<td>40</td>
</tr>
<tr>
<td>CW</td>
<td>0.05%</td>
</tr>
<tr>
<td>JC</td>
<td>0.5</td>
</tr>
<tr>
<td>TT</td>
<td>0.8</td>
</tr>
<tr>
<td>SC</td>
<td>0.8</td>
</tr>
<tr>
<td>BF</td>
<td>0.8</td>
</tr>
<tr>
<td>LN</td>
<td>0.5</td>
</tr>
<tr>
<td>EC</td>
<td>0.8</td>
</tr>
<tr>
<td>PMC</td>
<td>0.5</td>
</tr>
<tr>
<td>IC</td>
<td>0.8</td>
</tr>
<tr>
<td>VR</td>
<td>0.8</td>
</tr>
<tr>
<td>VS</td>
<td>0.8</td>
</tr>
<tr>
<td>MS</td>
<td>0.8</td>
</tr>
<tr>
<td>LT</td>
<td>0.5</td>
</tr>
</tbody>
</table>

### 3. FUZZY AHP

By using this method, combine the relative weight of criteria to measure the fuzzy judgment matrix consequently, the weight vector matrix must be calculated firstly. Afterwards multiply the fuzzy judgment matrix by the corresponding fuzzy vector.
A NEW HYBRID METHODOLOGY FOR SELECTION OF THIRD PARTY LOGISTICS

weight to attain the fuzzy performance matrix. The notations usually used in the paper are below:

- $A_i$: an alternative $i$ or a supplier $i$, $i = 1, 2, ..., n$;
- $C_j$: a criterion $j$, $j = 1, 2, ..., m$;
- $C_{jk}$: a sub-criterion $jk$ under criteria $j$, $k = 1, 2, ..., q$;
- $D_p$: a decision maker $p$, $p = 1, 2, ..., t$;
- $\tilde{G}_{ijkp}$: a grade of alternative $i$, with respect to decision maker $p$ on sub-criterion $jk$;
- $\tilde{G}_{ijk}$: a sub-score of alternative $i$, with respect to a sub-criterion $jk$;
- $\tilde{G}_{ij}$: a score of alternative $i$, with respect to a criterion $j$;
- $a_{ij}$: the judgement score of alternative $i$, with respect to criterion $j$;
- $b_{jep}$: a score, which a decision maker $p$ evaluates the relative importance between criterion $j$ and criterion $e$, $e = 1, 2, ..., m$;
- $b_{je}$: a comprehensive score, which the relative importance between criterion $j$ and criterion $e$ with triangular fuzzy numbers;
- $W_j$: a weight with respect to a specific criterion $j$;
- $h_{ij}$: the fuzzy performance score, which alternative $i$ corresponds to criterion $j$ with triangular fuzzy numbers;
- $\alpha$: the decision makers' degree of confidence, $0 \leq \alpha \leq 1$;
- $\beta$: the risk index, $0 \leq \beta \leq 1$;
- $h_{ij}^{a\beta}$: the crisp performance score of each alternative $i$ with respect to criterion $j$ under $\alpha$ degree of confidence and $\beta$ risk level;
- $[h_{ij}^a, h_{ij}^\alpha]$: the best and the worst crisp performance score result across all alternatives on criterion $j$;

Step 3.1: Obtain the Fuzzy Judgement Matrix

For attaining judgment matrix, firstly in order to acquire the scores $\tilde{G}_{ij}$ which each alternative corresponds to all criteria, we use Eq. (1) to separately sum up all the scores of each alternative with respect to sub-criteria which belong to same criterion.

$$\tilde{G}_{ij} = \sum_{k=1}^{q} \tilde{G}_{ijk}, i = 1, 2, ..., n; j = 1, 2, ..., m; k = 1, 2, ..., q$$

The scores may be deduced by analogy. After acquiring all sub-scores, a matrix can be formed as
A normalization process is implemented. Each criterion shown above matrix is normalized by Eq. (2). The fuzzy judgement matrix \((A)\) is shown below after normalizing.

\[
a_{ij} = \frac{\tilde{G}_{ij}}{\sqrt{\sum_{i=1}^{n} (\tilde{G}_{ij})^2}}, \quad j = 1,2,\ldots,m
\]

Judgement scores for each alternative with respect to criteria after normalization process is calculated. Then fuzzy judgment matrix \((A)\) is shown below.

**Step 3.2: Calculate Fuzzy Performance Matrix**

In this section, join relative weights of these criteria to measure the fuzzy judgment matrix. Consequently, the weight vector must be calculated firstly afterward multiply judgment matrix by corresponding fuzzy weight vector to attain fuzzy performance matrix.

### 3.2.1 Construct Fuzzy Weight Vector

The fuzzy weight vector is operated by applying pair wise comparisons of the AHP. But it is hard to avoid the decision makers subjective judgment for this reason, the group decision with the AHP is employed to convert into fuzzy form. We let three decision makers respectively compare relative importance between each criterion three pair wise comparisons.

\[
A = \begin{bmatrix}
0.3686 & 0.6909 & 1.2851 \\
0.3030 & 0.6550 & 1.3392 \\
0.2504 & 0.3716 & 0.5793 & 0.8930 \\
0.5070 & 0.9888 & 0.2504 & 0.3718 & 0.7063
\end{bmatrix}
\]

<table>
<thead>
<tr>
<th></th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>(18 16 32)</td>
<td>(17 27 35)</td>
<td>(20 28 32)</td>
<td>(9 15 21)</td>
</tr>
<tr>
<td>B</td>
<td>(14 22 28)</td>
<td>(15 23 31)</td>
<td>(28 36 36)</td>
<td>(17 23 25)</td>
</tr>
<tr>
<td>C</td>
<td>(10 16 24)</td>
<td>(13 21 31)</td>
<td>(10 16 24)</td>
<td>(9 11 15)</td>
</tr>
</tbody>
</table>
A New Hybrid Methodology for Selection of Third Party Logistics / 9

Then, a comprehensive pairwise comparison matrix is built by integrating all decision maker’s grades \( (b_{jep}) \) through Eq. (3)-(6)

\[
L_{je} = \min(b_{jep}), \quad p = 1,2,...,t \quad j = 1,2,....m \quad e = 1,2,....m
\]

\[
M_{je} = \frac{\sum_{p=1}^{t} b_{jep}}{p}, \quad p = 1,2,.....t \quad j = 1,2,....m \quad e = 1,2,......m
\]

\[
U_{je} = \max(U_{jep}), \quad p = 1,2,.....t \quad j = 1,2,..m \quad e = 1,2,...m
\]

\[
b_{je} = (L_{je}, M_{je}, U_{je}), \quad j = 1,2,.........m \quad e = 1,2,........m
\]

Then, a comprehensive pairwise comparison matrix is established below:

<table>
<thead>
<tr>
<th></th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>C2</td>
<td>1/2</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>C3</td>
<td>1/5</td>
<td>1/2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>C4</td>
<td>1/6</td>
<td>1/5</td>
<td>1/2</td>
<td>1</td>
</tr>
</tbody>
</table>

The importance of each criterion is different. In order acquire a weight which corresponds to each criterion, we determine an equation to calculate relative weights between all criteria. Each criterion weight are sequentially solved by Eq.(7).

\[
W_j = \frac{\sum_{e=1}^{m} b_{je}}{\sum_{j=1}^{m} \sum_{e=1}^{m} b_{je}}, \quad j = 1,2,...m \quad e = 1,2,....m
\]

These criteria weights collectively make up a fuzzy weight vector \((W)\).

\[
W = (W_1 \ W_2 \ W_3 \ W_4)
\]

3.2.2 Synthesize

Here we synthesize the fuzzy judgement matrix \((A)\) and the fuzzy weight vector \((w)\).

We individually take each criterion weight to multiply its corresponding criterion in the fuzzy judgement matrix is shown below:
Step 4: Determine the Crisp Performance Matrix

During supplier selection process unobvious factors which usually are ignored may deeply affect the decision results. In this section, the decision maker’s degree of confidence and risk issues are brought up during defuzzyfication process so as to approach the real decision environment of supplier selection.

(a) JOIN $\alpha$-CUT

The value of $\alpha$ indicates the decision maker’s degree of confidence in their subjective evaluation concerning alternative scores and criteria weight. The higher value expresses the degree of confidence and closer to the possible value of triangular numbers. Here three decision makers considered they have commanded enough information, knowledge and data to overcome uncertainty in their evaluation for supplier selection problem, so set up $\alpha$ value = 0.85. Then the interval value $[h_{ij}^{\alpha}, h_{ijr}^{\alpha}]$ can be sequentially solved by using Eq.(8)-(9)

$$h_{ij}^{\alpha} = L_{ij} + \alpha(M_{ij} - L_{ij}) $$

$$h_{ijr}^{\alpha} = U_{ij} - \alpha(U_{ij} - M_{ij})$$

The remaining intervals may be deduced by analogy. After ward the interval performance with $\alpha = 0.85$ can be completely built in the following:

$$H^{0.85} = \begin{pmatrix}
(0.326, 0.448) & (0.180, 0.263) & (0.073, 0.096) & (0.023, 0.023) \\
(0.027, 0.384) & (0.153, 0.227) & (0.094, 0.119) & (0.030, 0.040) \\
(0.199, 0.295) & (0.140, 0.214) & (0.041, 0.153) & (0.017, 0.020)
\end{pmatrix}$$

(b) Join Risk Issue

The potential decision maker risk issues encompass the supplier selection problem
A NEW HYBRID METHODOLOGY FOR SELECTION OF THIRD PARTY LOGISTICS

within a supply chain. In our proposed approach, we allow the decision maker’s to adjust risk index $\beta$ on the other hand three decision makers uniformly considered 0.2 is the risk value to match the real situation. After determining the $\beta$ value we can implement defuzzyfication process to acquire crisp performance scores by solving below equation

$$h_{ij}^\alpha = \beta h_{ij}^\alpha + (1 - \beta)h_{ij}^{\alpha'}, 0 \leq \alpha, 0 \leq \beta \leq 1$$ (10)

The remaining crisp performance scores may be deduced by analogy. Then, the overall crisp performance matrix $H_\beta^\alpha$ with $\alpha = 0.85$ and $\beta = 0.2$. The overall crisp performance matrix $H_\beta^\alpha$ is shown below.

Overall Crisp Performance Matrix

<table>
<thead>
<tr>
<th>Vendors/Criteria</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.4238</td>
<td>0.24674</td>
<td>0.0918</td>
<td>0.0304</td>
</tr>
<tr>
<td>B</td>
<td>0.3616</td>
<td>0.2126</td>
<td>0.1146</td>
<td>0.0440</td>
</tr>
<tr>
<td>C</td>
<td>0.2758</td>
<td>0.1997</td>
<td>0.3332</td>
<td>0.0229</td>
</tr>
</tbody>
</table>

4. FINAL RANKING

We find each supplier has its advantages on different criteria. Consequently we must employ an effective technique. Hence MODIFIED REGIME is used to balance crisp performance scores and execute final ranking.

4.1 Modified Regime

It is a metric procedure and it is based on the evaluation of all possible rankings (permutations) of alternatives under consideration. This method is based on the comparison among the comprehensive ranking of the alternatives and the evaluations of alternatives according to each criterion from family $F$ (impact matrix) as shown in below table 4.

Table 4

<table>
<thead>
<tr>
<th>Rank Evaluation all Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
</tbody>
</table>

For each permutation, one computes a concordance/discordance index for each couple of alternatives that reflects the concordance and the discordance of their ranks and their evaluation preorders from the impact matrix. Given the set of alternatives $A$, the concordance/discordance index for each couple of alternatives $(a, b), a, b \in A$, at
the level of preorder according to the criterion \( g_j \) \( F \) and the ranking corresponding to the \( K \)th permutation is:

\[
I_{jk}(a, b) = \begin{cases} 
    r_{ij} - r_{kj} & \text{if there is concordance} \\
    0 & \text{if there is ex aequo} \\
    r_{kj} - r_{ij} & \text{if there is discordance}
\end{cases}
\]

Where \( r_{il} (r_{li}) \) is the rank of the alternative \( a_i (a_l) \) according to criterion when two alternatives are compared on all criteria. When two alternatives are compared on all criteria, it is possible to form a vector \( c_{il} = (c_{il,1}, \ldots, c_{il,j}, \ldots, c_{il,n}) \) that is called a regime and the regime matrix is formed of these regimes. These regimes will be used to determine rank order of alternatives. The combinations are \( C_{AB}, C_{AC}, C_{BA}, C_{BC}, C_{CA}, C_{CB} \).

The concordance index, in favor of the combination \( C_{AB} \) is given by:

\[
C_{AB} = +1 \text{ (since } A > B \text{ for criterion } g1); \\
C_{AB} = -1 \text{ (since } B > A \text{ for criterion } g3); \\
C_{AC} = +2 \text{ (since } A > C \text{ for criterion } g1);
\]

Combination 1: \( C_{AB}: A > B \) for criterion \( g1 \), and so that gives \((2-1)\) for the couple. Thus the value of index \( I_{11} \) is equal to +1.

Combination 3: \( C_{AC}: A > C \) for criterion \( g1 \), and so that gives \((3-1)\) for the couple. Thus the value of index \( I_{21} \) is equal to +2.

Similarly for all combinations we calculate concordance and discordance indices.

### The Concordance/discordance Indices

<table>
<thead>
<tr>
<th>Combination</th>
<th>( g1 )</th>
<th>( g2 )</th>
<th>( g3 )</th>
<th>( g4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A,B</td>
<td>+1</td>
<td>+1</td>
<td>-1</td>
<td>+1</td>
</tr>
<tr>
<td>A,C</td>
<td>+2</td>
<td>+2</td>
<td>-2</td>
<td>+1</td>
</tr>
<tr>
<td>B,A</td>
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<td>-1</td>
<td>+1</td>
<td>+1</td>
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<tr>
<td>B,C</td>
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<td>+1</td>
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<td>+2</td>
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<tr>
<td>C,A</td>
<td>-2</td>
<td>-2</td>
<td>+2</td>
<td>-1</td>
</tr>
<tr>
<td>C,B</td>
<td>-1</td>
<td>-1</td>
<td>+1</td>
<td>-2</td>
</tr>
</tbody>
</table>

The comprehensive concordance/discordance index between the pre-order according to the criterion \( g_j \) and the ranking corresponding to the \( K \)th permutation is:

\[
C_{il} = \sum_j \pi_j c_{il,j},
\]

Therefore for combination 1:

\[
I_1 = (1*0.5358) + (1*0.233228) + (-1*0.1445) + (1*0.0524) \\
= 0.57118.
\]
Likewise for all combinations, the comprehensive concordance/discordance indices are:

\[ I_2 = 1.29956 \quad I_3 = 0.72838 \quad I_4 = -0.57718 \quad I_5 = -0.72838 \quad I_6 = -1.29956 \]

At a comprehensive level with respect to all possible rankings, one tries to identify the combinations that is greater than zero. So here \( A > B, A > C, B > C \). Therefore from these we identify that the best 3PL provider is given by \( A > B > C \).

Therefore ‘A’ is more preferred than ‘B’ and ‘C’.

5. CONCLUSION

Performance measurement involves strategic decision making which consists of a number of factors. Performance measurement which is an active academic research area has been an important problem in successful Business. The performance evaluation model uses fuzzy analytic hierarchical process and approximate reasoning. The proposed fuzzy AHP approach consists of constructing an AHP comparison matrix with default pairwise evaluation of factors using fuzzy numbers. The use of fuzzy numbers enables to account for the inherent subjectivity in pairwise comparison. The comparison consists operates on rules that are formed with fuzzy numbers via fuzzy AHP derived from expert’s. Because different experts will have different personal knowledge bases, different confidence levels and attitudes would be embedded in the structure of these rules. Thus, such differences will influence the final score obtained with the application of these rules formed with fuzzy AHP. There are several other aspects of the performance measurement process that are open for exploration. It can be claimed that in this instance there are no clear decisions as to the best option between vendor A, vendor B and vendor C since the difference is very low. It was found that (fuzzy AHP + MODIFIED REGIME) is the best hybrid method which yields consistent results for the above case study. Since fuzzy AHP+MODIFIED REGIME), shows the gap between the final weights of three vendors is large. Hence we can easily make clear decisions between three vendors.

REFERENCES


