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THIRD PARTY LOGISTIC SERVICE PROVIDER SELECTION USING FUZZY AHP AND TOPSIS METHOD

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Abstract: *The use of third party logistic (3PL) services providers is increasing globally to accomplish the strategic objectives. In the increasingly competitive environment, logistics strategic management requires systematic and structured approach to have cutting edge over the rival. Logistics service provider selection is a complex multi-criteria decision making process; in which, decision makers have to deals with the optimization of conflicting objectives such as quality, cost, and delivery time. In this paper, fuzzy analytic hierarchy process (FAHP) approach based on technique for order preference by similarity to ideal solution (TOPSIS) method has been proposed for evaluating and selecting an appropriate logistics service provider, where the ratings of each alternative and importance weight of each criterion are expressed in triangular fuzzy numbers.*

Keywords: *FAHP, Logistics service provider selection, TOPSIS technique, 3PL*

1. INTRODUCTION

The continued growth across the globe is leading, the business development, whereas, information technology (IT) and freedom from licensing has given rise to globalization. Globalization of business has been considered, the driving force for outsourcing by many researchers (Foster and Muller 1990) as the most influential. The logistics service provider selection is a complex multi-criteria problem that includes both quantitative and qualitative criteria some of which can conflict each other and is vital in enhancing the competitiveness of companies (Çakır 2009; Güner 2005). While choosing the appropriate provider, logistics managers might be uncertain whether the selection will satisfy completely the needs of the organization Bevilacqua and Petroni (2002). Verma and Pulman (1998) examined the difference between managers' ratings of the perceived importance of different supplier attributes and their actual choice of suppliers in an experimental setting. They used two methods: a Likert scale set of questions and a discrete choice analysis (DCA) experiment. Ghodsypour and O'Brien (1998) proposed an integration of analytical hierarchy process (AHP) and linear programming to consider both tangible and intangible factors for choosing the best suppliers and placing the optimum order quantities among them such that the total value of purchasing becomes maximum.

Analytical Hierarchy Process provides the objective mathematics to process the intuitive, rational, irrational factors and personal preference of the individual or a group in making a decision. The strength of the AHP lies in its ability of structuring complex, multi-person and multi-attribute problems hierarchically and investigating each level of the hierarchy separately combining the results. Bevilacqua and Petroni (2002) developed a system for supplier selection using fuzzy logic (FL). FL; which was introduced by Zadeh (1965) with his pioneer work "Fuzzy Sets", can simply be defined as "a form of mathematical logic in which truth can assume a continuum of values between 0 and 1". As fuzzy set theory became an important problem modeling and solution technique due to its ability of modeling problems quantitatively and qualitatively those involve vagueness and imprecision (Kahraman 2006), it has been successfully applied many disciplines such as control systems, decision making, pattern recognition, system modeling and etc. in fields of scientific researches as well as industrial and military applications. Kahraman et al. (2003) used fuzzy AHP (FAHP) to select the best supplier firm for a white good manufacturer established in Turkey providing the most satisfaction. Xia and Wu (2007) proposed an integrated approach of AHP (improved by rough sets theory and multi-objective mixed integer programming) to simultaneously determine the number of suppliers for employing and the order quantity allocated to these suppliers in the case of multiple sourcing, multiple products with multiple criteria and supplier's capacity constraints.

In this paper a decision support system for logistics service provider selection based on a FAHP model and TOPSIS method is designed and implemented. The following sections of the paper are organized as follow. In section 2, Fuzz set theory and TOPSIS model are introduced. In section 3, application of fuzzy AHP and TOPSIS methodology is demonstrated. In our methodology first by using improved AHP with fuzzy set theory, the weight of each criterion is calculated. Then this article introduces a model that integrates improved fuzzy AHP with TOPSIS algorithm to support appropriate logistics service provider selection decisions. Finally, discussions are provided in section 4.

2. FUZZY SETS THEORY AND TOPSIS METHOD

Fuzzy set theory

Zadeh (1965) came out with the fuzzy set theory to deal with vagueness and uncertainty in decision making in order to enhance precision. Thus the vague data may be represented using fuzzy numbers, which can be further subjected to mathematical operation in fuzzy domain. Thus fuzzy numbers can be represented by its membership grade ranging between 0 and 1. A triangular fuzzy number (TFN) $\tilde{M}$ is shown in Figure 1 (Kabir and Hasin 2011).

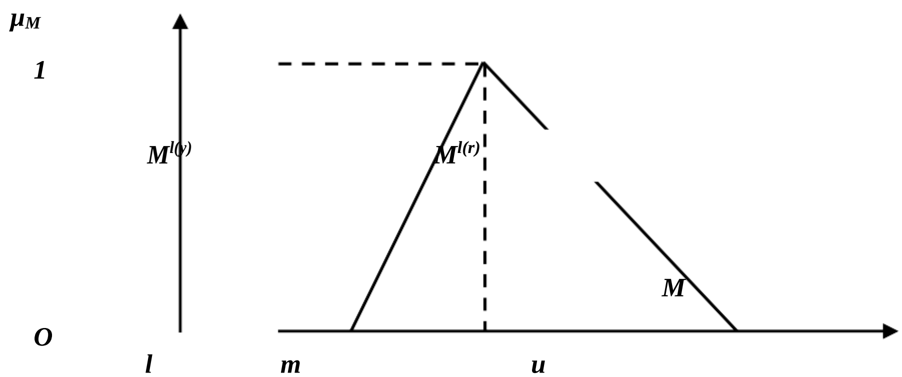

Figure 1.

A TFN is denoted simply as (l/m, m/u) or (l, m, u), represents the smallest possible value, the most promising value and the largest possible value respectively. The TFN having linear representation on left and right side can be defined in terms of its membership function as:

$$\mu\ (x\backslash\tilde{M}) = \begin{cases} 0, & x < l, \\ (x-l)/(m-l), & l \leq x \leq m \\ (u-x)/(u-m), & m \leq x \leq u, \\ 0, & x > u, \end{cases} \qquad (1)$$

A fuzzy number with its corresponding left and right representation of each degree of membership is as below:

$\tilde{M} = (M^{l(y)}, M^{l(r)}) = (l+(m-l)\,y, u+(m-u)\,y), y\ \varepsilon[0,1]$ (2)

where $l(y)$ and $l(r)$ denotes the left side representation and the right side representation of a fuzzy number respectively (Kabir 2011).

The fuzzy summation $\oplus$ and fuzzy subtraction Θ of any two TFN are also TFNs, but the multiplication $\otimes$ of any two TFNs is only approximate TFNs. The data can be assessed using Table 1, which shows the linguistics scale along with corresponding triangular fuzzy scale.

Table 1: Triangular fuzzy conversion scale

Linguistic Scale	Triangular Fuzzy Scale	Triangular Fuzzy Reciprocal Scale
Just equal	1, 1, 1	1, 1, 1
Equally important	1/2, 1, 3/2	2/3, 1, 2
Weakly important	1, 3/2, 2	1/2, 2/3, 1
Strongly more important	3/2, 2, 5/2	2/5, 1/2, 2/3
Very strongly more important	2, 5/2, 3	1/3, 2/5, 1/2
Absolutely more important	5/2, 3, 7/2	2/7, 1/3, 2/5

Source: Bozbura and Beskese 2007

If $\tilde{M}_1 = (a_1, b_1, c_1)$ and $\tilde{M}_2 = (a_2, b_2, c_2)$ are two TFNs, then their operational laws can be expressed as follows:

$$\tilde{M}_1 \oplus \tilde{M}_2 = a_1 + a_2, b_1 + b_2, c_1 + c_2 \quad (3)$$
$$\tilde{M}_1 \Theta \tilde{M}_2 = a_1 - a_2, b_1 - b_2, c_1 - c_2 \quad (4)$$
$$\tilde{M}_1 \otimes \tilde{M}_2 = a_1 a_2, b_1 b_2, c_1 c_2 \quad (5)$$
$$\lambda \otimes \tilde{M}_1 = \lambda a_1, \lambda b_1, \lambda c_1 \text{ where } \lambda > 0, \lambda \in R \quad (6)$$
$$\tilde{M}_1^{-1} = (1/c_1, 1/b_1, 1/a_1) \quad (7)$$

Fuzzy analytic hierarchy process

The following section outlines the extent analysis method on FAHP. Let $X = \{x_1, x_2, \ldots, x_n\}$ be an object set and $U = \{u_1, u_2, \ldots, u_m\}$ be a goal set. As per Chang (1992, 1996) each object is taken and analysis for each goal, g_i, is performed, respectively. Therefore m extent analysis values for each object can be obtained, as under:

$$M_{g_i}^1, M_{g_i}^2, \ldots, M_{g_i}^m, \quad i = 1, 2, 3, \ldots, n \quad (8)$$

where all the $M_{g_i}^m$ ($j = 1, 2, \ldots, m$) are TFNs whose parameters are, depicting least, most and largest possible values respectively and represented as (a, b, c).

The steps of Chang's extent analysis (Chang, 1992) can be detailed as follows (Bozbura et al., 2007; Kahraman et al., 2004; Kabir and Hasin 2012; Bahram and Asghari, 2011):

Step 1: The value of fuzzy synthetic extent with respect to i th object is defined as

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j\right]^{-1} \quad (9)$$

To obtain $\sum_{j=1}^{m} M_{g_i}^j$ perform the fuzzy addition operation of m extent analysis values for a particular matrix such that

$$\sum_{j=1} M_g = \left(\sum_{j=1} a_j, \sum_{j=1} b_j, \sum_{j=1} c_j\right) \quad (10)$$

And to obtain $\left[\sum_{i=1}\sum_{j=1}^{m} M_{g_i}\right]$ perform the fuzzy addition operation of M_{g_i} ($j = 1, 2, \ldots, m$) values such that

$$\sum_{i=1}\sum_{j=} M_{g_i} = \left(\sum_{i=1} a_i, \sum_{i=1} b_i, \sum_{i=1} c_i\right) \quad (11)$$

And then compute the inverse of the vector in equation (11) such that

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} c_i}, \frac{1}{\sum_{i=1}^{n} b_i}, \frac{1}{\sum_{i=1}^{n} a_i}\right) \quad (12)$$

Step 2: The degree of possibility of $M_2 = (a_2, b_2, c_2) \geq M_1 = (a_1, b_1, c_1)$ is defined as

$$V(M_2 \geq M_1) = \sup[\min(\mu_{M_1}(x), \mu_{M_2}(x))] \quad (13)$$

And can be equivalently expressed as follows

$$V(\tilde{M}_2 \geq \tilde{M}_1) = hgt(\tilde{M}_1 \cap \tilde{M}_2) \quad \begin{cases} 1, & \text{if } b_2 \geq b_1 \\ -, & \text{If } a_1 \geq c_2 \\ \dfrac{1 \quad c_2}{(b_2 - c_2) - (b_1 - a_1)}, & \text{rwise} \end{cases} \quad (14)$$

where d is the ordinate of the highest intersection point D between μ_{M_1} and μ_{M_2} as shown in Figure 2.

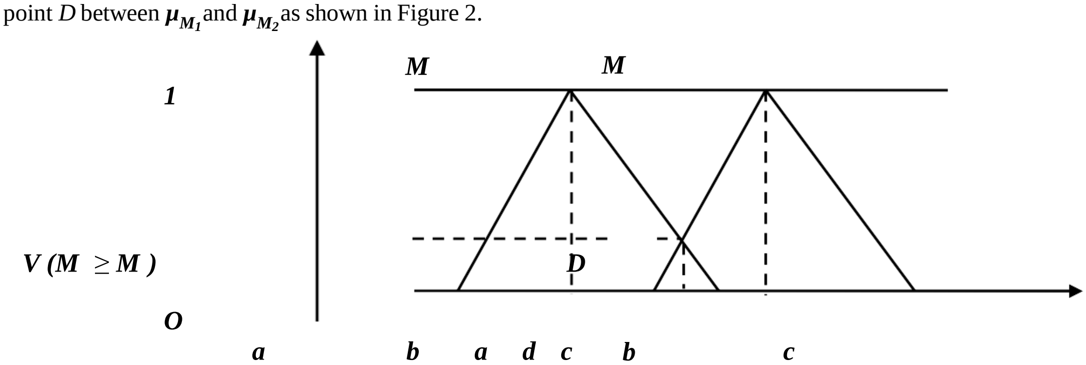

Figure 2: The intersection between M_1 and M_2

To compare M_1 and M_2, both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$. *Step 3:* The degree of ossibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i ($i = 1, 2, \ldots, k$) can be defined by

$V(M \geq M_1, M_2, \ldots, M_k) = V[(M \geq M_1)$ and $(M \geq M_2)$ and $\ldots (M \geq M_k)]$ (15)

$= \min V(M \geq M_i)$, (i = 1, 2, 3 ,…., k)

Assuming that

$d'(A_i) = \min V(S_i \geq S_k)$ (16)

for $k = 1, 2, 3, \ldots, n; k \neq i$. Then the weight vector is given by

$W' = (d'(A_1), d'(A_2), \ldots, d'(A_n))^T$ (17)

where $A_i = (i = 1,2,3,\ldots n)$ are n elements

Step 4: By normalizing, the normalized weight vectors are

$W = (d(A_1), d(A_2), \ldots, d(A_n))^T$ (18)

where W is a non-fuzzy number.

TOPSIS Method

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is one of the useful Multi Attribute Decision Making techniques that are very simple and easy to implement, so that it is used when the user prefers a simpler weighting approach. On the other hand, the AHP approach provides a decision hierarchy and requires pairwise comparison among criteria. The user needs a more detailed knowledge about the criteria in the decision hierarchy to make informed decisions in using the AHP (Lee 2001). TOPSIS method was firstly proposed by Hwang and Yoon (1981). According to this technique, the best alternative would be the one that is nearest to the positive ideal solution and farthest from the negative ideal solution (Benitez et al. 2007). The positive ideal solution is a solution that maximizes the benefit criteria and minimizes the cost criteria, whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria (Wang and Elhag 2006; Wang and Lee 2007). In other words, the positive ideal solution is composed of all best values attainable of criteria, whereas the negative ideal solution consists of all worst values attainable of criteria (Ertuğrul and Karakasoğlu 2009; Stank *et al.*, 1998). In this study, TOPSIS method is used for determining the final ranking of the logistics service providers. The method is calculated as follows:

Step 1: Construct normalized decision matrix.

This step transforms various attribute dimensions into non-dimensional attributes, which allows comparisons across criteria. Normalize scores or data as follows:

$r_{ij} = x_{ij} / (\Sigma x^2_{ij})^{1/2}$ for i = 1, …, m; j = 1, …, n (19)

Step 2: Construct the weighted normalized decision matrix.

Assume we have a set of weights for each criteria w_j for j = 1,…n. Multiply each column of the normalized decision matrix by its associated weight. An element of the new matrix is:

$v_{ij} = w_j r_{ij}$, for i = 1, …, m; j = 1, …, n(20)

Step 3: Determine the positive ideal and negative ideal solutions.

Positive Ideal solution:

$A^* = \{ v_1^*, \ldots, v_n^* \}$, where $v_j^* = \{ \max(v_{ij})$ if $j \in J$; $\min(v_{ij})$ if $j \in J' \}$ (21)

Negative ideal solution:

$A' = \{ v_1', \ldots, v_n' \}$, where $v' = \{ \min(v_{ij})$ if $j \in J$; $\max(v_{ij})$ if $j \in J' \}$ (22)

Step 4: Calculate the separation measures for each alternative.

The separation from the ideal alternative is:

$D_i^* = [\Sigma (v_j^* - v_{ij})^2]^{½}$ i = 1, …, m (23)

Similarly, the separation from the negative ideal alternative is:

$D'_i = [\Sigma (v_j' - v_{ij})^2]^{½}$ i = 1, …, m (24)

Step 5: Calculate the relative closeness to the ideal solution CC_i^*

$CC_i^* = S'_i / (S_i^* + S'_i)$, $0 < CC_i^* < 1$ (25)

Step 6: By comparing CC_i^* values, the ranking of alternatives are determined.

3. EMPIRICAL STUDY

The application of the fuzzy AHP approach and TOPSIS method is demonstrated for a medium-sized and growth-oriented fast-moving-consumer-goods (FMCG) company, which is steadily moving towards IT enablement of its supply chain (Spencer *et al.*, 1994; Kalpande et al., 2010). It has partially outsourced its outbound logistics to carrying and forwarding agents. The company is willing to outsource its entire logistics activities. The goal is to choose the best logistics service provider for a case company. So, this goal is placed at the top of the hierarchy. The hierarchy descends from the more general criteria in the second level to the alternatives at the bottom level.

Based on the extensive literature survey, various logistics criteria or factors have been identified, however looking to the requirement of the present case study decision-makers (DMs) restricted them to six only, they are identified as *compatibility, financial stability, flexibility, operational performance, quality management* and *reputation of the 3PL services provider.* These criteria have been discussed in brief.

Compatibility is very important as it enables the user and the provider to work together. Bowersox and Daugherty (1990) identify compatibility of culture and values, as one of the keys to successful partnership which can result in long-term relationship. As per empirical study of Boyson et al. (1999) compatibility with company culture and philosophy attribute, was ranked second in the degree of importance.

Similarly *financial stability* plays an important role in order management. As per Bowersox and Daugherty (1990) financially sound 3PL services provider boosts customer satisfaction and reduces cost through a dedicated resource base, it also reduces logistical risks for partnering firm.

Flexibility in operation and delivery characterize a potential criteria for a 3PL services providers, it can pull customers (1998) hence becomes shippers' obvious choice. Flexibility in services plays an important role in rapidly changing customers' need and market scenario. 3PL services provider may foster the shippers' ambitious plan of meeting the customers' fast changing need in real time through flexibility in services, thus, it entails an important criterion needed for the 3PL services providers.

Operational performance indicates IT capability, size and quality of fixed assets, delivery performance level, employee satisfaction level etc. Size and quality of fixed assets help the 3PL services providers to discharge their duties efficiently. The availability of the appropriate physical equipment their size and the quality must be assessed before selecting 3PL services providers. Hum (2000) called for the strategic logistics capabilities in order to have strategic positioning of 3PL services providers and further emphasized to nurture the in-house resources and expertise (intellectual assets).

Quality management infuses innovativeness and responsiveness in the system to guarantee high service level. 3PL services provider is attributed to increase the customer satisfaction by timely delivering and maintaining the commitment of high service level. The ability to provide quantitatively measurable performance is among the most important criteria when choosing a provider (1994).

Reputation of the 3PL services provider plays an important role in highlighting its selection. Reputation also helps to build the customer relationship which boosts the long-term business.

Four logistics service providers are considered for the decision alternatives, and located them on the bottom level of the hierarchy. These are $3PL_S$, $3PL_K$, $3PL_T$ and $3PL_L$, where S, K T & L indicates the first letter of the respective logistic services provider. Figure 3 illustrates a hierarchical representation of selecting best logistics service provider decision-making model.

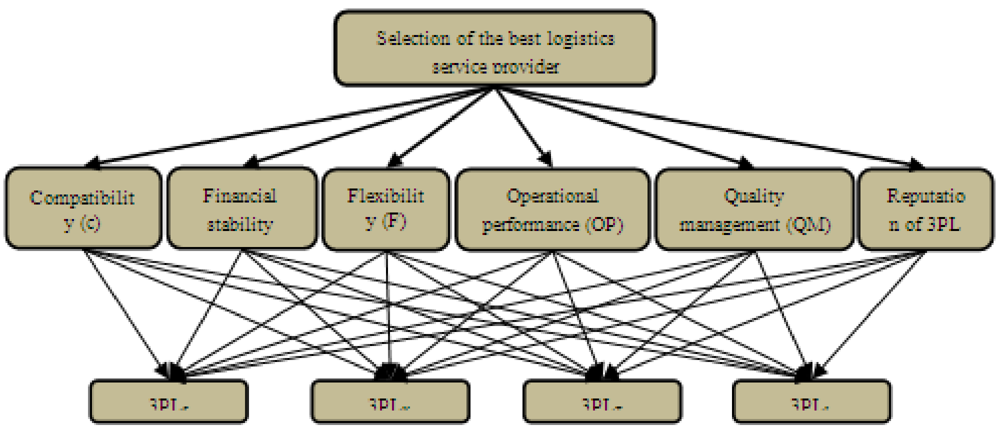

Figure 3: Hierarchical representation of best logistics service provider selection

The use of ratings enables DMs to analyze each LSP individually with respect to each criterion for their subsequent ranking relative to each other. A decision matrix '***D***' as shown in Table 2 may be constructed to measure the relative degree of importance for each logistics criteria or attributes, based on the proposed methodology. The decision matrix consist 6×6 elements.

Table 2: Decision matrix 'D' for main attributes

Attributes	C	FS	F	OP	QM	R
C	1,1,1	2/5,1/2,2/3	2,5/2,3	5/2,3,7/2	2/7,1/3,2/5	1/2,2/3,1
FS	3/2,2,5/2	1,1,1	2,5/2,3	3/2,2,5/2	2,5/2,3	2/3,1,2
F	1/3,2/5,1/2	1/3,2/5,1/2	1,1,1	2/3,1,2	7/2,4,9/2	1/3,2/5,1/2
OP	5/2,3,7/2	2/5,1/2,2/3	1/2,1,3/2	1,1,1	5/2,3,7/2	1,1,1
QM	(5/2,3,7/2)	(1/3,2/5,1/2)	(2/9,1/4,2/7)	(2/7,1/3,2/5)	(1,1,1)	(5/2,3,7/2)
R	(1,3/2,2)	(1/2,1,3/2)	(2,5/2,3)	(1,1,1)	(5/2,3,7/2)	(1,1,1)

Inconsistency of TFN used can be checked and the consistency ratio (CR) may be calculated [26]. The results obtained are: $\lambda_{max} = 6.5342$; CI = 0.1068; RI = 1.24 and CR = 0.0862. As CR < 0.1 the level of inconsistency present in the information stored in '***D***' matrix is satisfactory (Saaty 1998).

S_C= (6.69, 8.00, 9.57) $\otimes$ (1/58.72, 1/48.35, 1/39.83) = (0.11, 0.17, 0.24)

S_{FS}= (8.67, 11.00, 14.00) $\otimes$ (1/58.72, 1/48.35, 1/39.83) = (0.15, 0.23, 0.35)

S_F= (6.17, 7.20, 9.00) $\otimes$ (1/58.72, 1/48.35, 1/39.83) = (0.11, 0.15, 0.23)

S_{OP}= (7.90, 9.50, 11.17) $\otimes$ (1/58.72, 1/48.35, 1/39.83) = (0.13, 0.20, 0.28)

S_{QM}= (6.84, 7.78, 9.18) $\otimes$ (1/58.72, 1/48.35, 1/39.83) = (0.12, 0.15, 0.23)

S_R= (8.00, 10.00, 12.00) $\otimes$ (1/58.72, 1/48.35, 1/39.83) = (0.14, 0.21, 0.30)

The degrees of possibility of superiority of S_C can be calculated by equations (14) and (16) and is denoted by V ($S_C \geq S_{FS}$). Therefore, the degree of possibility of superiority for the first requirement- the values are calculated as

V ($S_C \geq S_{FS}$) = 0.60, V ($S_C \geq S_F$) = 1.00, V ($S_C \geq S_{OP}$) = 0.77,

V ($S_C \geq S_{QM}$) = 0.77, V ($S_C \geq S_R$) = 0.72,

For the second requirement- the values are calculated as

V ($S_{FS} \geq S_C$) = 1.00, V ($S_{FS} \geq S_F$) = 1.00, V ($S_{FS} \geq S_{OP}$) = 1.00,

V ($S_{FS} \geq S_{QM}$) = 1.00, V ($S_{FS} \geq S_R$) = 1.00,

For the third requirement- the values are calculated as

V ($S_F \geq S_C$) = 0.87, V ($S_F \geq S_{FS}$) = 0.50, V ($S_F \geq S_{OP}$) = 0.66,

V ($S_F \geq S_{QM}$) = 1.00, V ($S_F \geq S_R$) = 0.61,

For the fourth requirement- the values are calculated as

V ($S_{OP} \geq S_C$) = 1.00, V ($S_{OP} \geq S_{FS}$) = 0.81, V ($S_{OP} \geq S_F$) = 1.00,

V ($S_{OP} \geq S_{QM}$) = 1.00, V ($S_{OP} \geq S_R$) = 0.93,

For the fifth requirement- the values are calculated as

V ($S_{QM} \geq S_C$) = 0.88, V ($S_{QM} \geq S_{FS}$) = 0.52, V ($S_{QM} \geq S_F$) = 1.00,

V ($S_{QM} \geq S_{OP}$) = 0.67, V ($S_{QM} \geq S_R$) = 0.62,

For the sixth requirement- the values are calculated as

V ($S_R \geq S_C$) = 1.00, V ($S_R \geq S_{FS}$) = 0.88, V ($S_R \geq S_F$) = 1.00,

V ($S_R \geq S_{OP}$) = 1.00, V ($S_R \geq S_{QM}$) = 1.00,

With the help of equation (17), the minimum degree of possibility of superiority of each criterion over another is obtained. This further decides the weight vectors of the criteria.

Therefore, the weight vector is given as

W' = (0.60, 1.000, 0.50, 0.811, 0.515, 0.881)

The normalized value of this vector decides the priority weights of each criterion over another. The normalized weight vectors are calculated as

W = (0.139, 0.232, 0.116, 0.188, 0.120, 0.205)

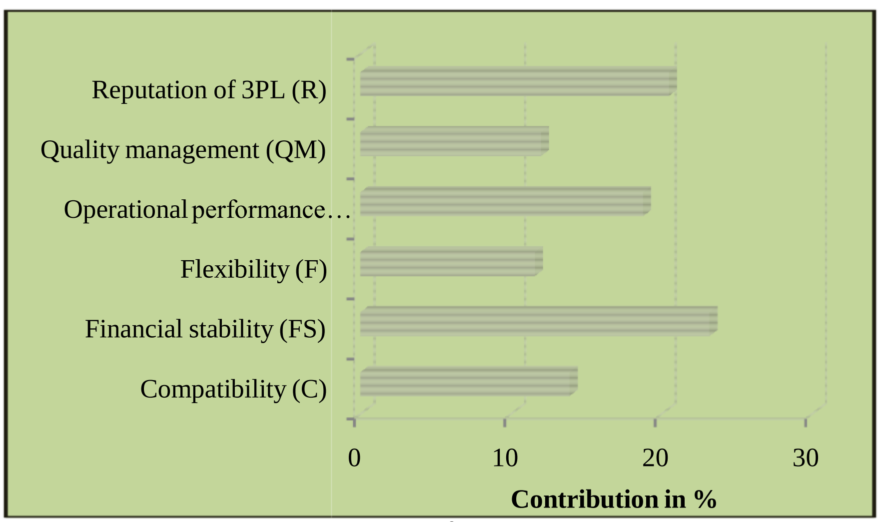

Figure 4: Contribution of criteria in percentage

The priority weight of each logistics service providers with respect to the each criterion has been determined following the similar procedure. Normalization of these values is made using equation (19) which shown in Table 3. Then, weighted normalized matrix is formed by multiplying each value with their weights.

Table 4 shows the normalized weighted decision matrix for each alternative with respect to the each criterion.

Table 3: Normalized decision matrix

Attributes/ Alternatives	C	FS	F	OP	QM	R
$3PL_S$	0.462	0.614	0.545	0.528	0.477	0.426
$3PL_K$	0.528	0.477	0.484	0.462	0.409	0.569
$3PL_T$	0.593	0.409	0.484	0.593	0.477	0.497
$3PL_L$	0.396	0.477	0.484	0.396	0.614	0.497

Table 4: Weighted normalized decision matrix

Attributes/ Alternatives	C	FS	F	OP	QM	R
$3PL_S$	0.0642	0.1424	0.0632	0.0993	0.0572	0.0873
$3PL_K$	0.0734	0.1107	0.0561	0.0869	0.0491	0.1166
$3PL_T$	0.0824	0.0949	0.0561	0.1115	0.0572	0.1019
$3PL_L$	0.055	0.1107	0.0561	0.0744	0.0737	0.1019

Positive and negative ideal solutions are determined by taking the maximum and minimum values for each criterion using equation (21) and (22). Then the distance of each alternative from PIS and NIS with respect to each criteria are calculated with the help of equation (23) and (24). Table 5 shows the separation measure of each alternative form PIS and NIS.

Table 5: Separation measure of each alternative

D_S^+	0.040135	D_S^-	0.05547
D_K^+	0.048442	D_K^-	0.04003
D_T^+	0.052868	D_T^-	0.04905
D_L^+	0.058297	D_L^-	0.03268

The closeness coefficient of each logistics service provider is calculated by using equation (25) and the ranking of the alternatives are determined according to these values in Table 6.

Table 6: Score of each project

$3PL_S$	0.41980
$3PL_K$	0.54754
$3PL_T$	0.51873
$3PL_L$	0.64078

Figure 5: Decision analysis graph

Figure 5 shows that service provider $3PL_L$ will be the best alternative. The order of ranking the alternatives using Fuzzy Analytical Hierarchy Process and TOPSIS method is $3PL_L > 3PL_K > 3PL_T > 3PL_S$.

4. CONCLUSIONS

Logistics service provider selection process becomes increasingly important in today's complex environment. The selection process involves the determination of quantitative and qualitative factors to select the best possible provider. In this study logistics service provider selection via extent fuzzy AHP and TOPSIS method has been proposed. The decision criteria are compatibility, financial stability, flexibility, operational performance, quality management and reputation of the 3PL services provider. These criteria were evaluated to obtain the preference degree associated with each logistics service provider alternative for selecting the most appropriate one for the company. By the help of the extent fuzzy approach, the ambiguities involved in the data could be effectively represented and processed to make a more effective decision.

As a result of this study, $3PL_L$ is determined as the best logistics service provider which has the highest priority weight. The company management found the application and results satisfactory and decided to work with $3PL_L$.

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