Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231– 6345 (Online)
An Open Access, Online International Journal Available at www.cibtech.org/sp.ed/jls/2016/02/jls.htm
2016 Vol. 6 (S2), pp. 435-447/Motaghi et al.
Research Article

INTEGRATING AHP AND STEM METHOD (FUZZY APPROACH) FOR SUPPLIER SELECTION AND ORDER ALLOCATION IN SPORTING GOODS MANUFACTURER COMPANY IN IRAN

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ABSTRACT
Establishing long-term relationships with a small number of suppliers is an important part of supply chain management. Therefore, supplier selection is a crucial strategic decision for long term survival of the firm. On the other hand, in the multi-criteria decision making problems, the weight of each alternative just calculated. The use of linear problem allow to selecting the optimal number of alternative with its allocations. In this paper a combined approach of fuzzy-AHP and fuzzy multi-objective linear programming are used. In this model fuzzy AHP is used first to calculate the weights of the criteria and then fuzzy linear programming is used to find out the optimum number the alternatives with the optimal its order allocations. The Result obtained indicates indicated that according to the criteria of the model Selecting and allocation ofordersto A_1, A_2, A_3 suppliers is more cost effective.

***Keywords**: Supplier Selection, Order Allocation, FAHP, FMLOP*

INTRODUCTION
Today, the companies are not unique business units and not able to work independently, but instead are part of a supply chain (Sunil Chopra, 2007). In this position, choosing appropriate set of suppliers is an important element for the success of the company. Supplier selection is one of the most important activities of acquisition as its results have a great impact on the quality and price of goods and performance of organizations and supply chains. Essentially, supplier selection is a decision process with the aim of reducing the initial set of potential suppliers to the final choices. Many researchers have considered their problem as a multi criteria decision making problem and they have applied various decision making methods (Carpinetti *et al.,* 2014; Asamoah *et al.,* 2012; Mehralian *et al.*, 2012; Dahel, 2003; Talluri & Narasimhan, 2006; Xia and Wu, 2007; Wang *et al.,* 2009; Büyüközkan, 2011; Buyüközkan and Cifc, 2012, Arikan, 2013).
Recently, with the advent of supply chain management, most of researchers, scientists and managers have realized that choosing a suitable supplier management tool can increase the competitiveness of the supply chain (Lee *et al.,* 2001). Nowadays, supplier selection with order allocation represents one of the most important functions to be performed by the purchasing decision makers, which determines the long-term viability of the company. Deciding on the order allocation is a strategic purchasing decision that will impact the firm's relationship with suppliers. In the supply chain scope, organizations should select the most appropriate suppliers for considerable products based on production capacity of available suppliers during the planning horizon. Department in an organization and it can intensively affect other processes within organization.
In this problem, the number and type of supplier, and the order quantities allocated to these suppliers should simultaneously be determined. Indeed, selection of suppliers and allocation of orders' quantity to each selected supplier are strategic purchasing decisions. Regarding how many suppliers can be considered to supply the required materials, the supplier selection problem can be categorized into two types as follows:

- Selecting the best supplier from the pool of available suppliers that can satisfy all buyer's requirements such as demand, quality, and delivery, etc. (single sourcing).

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- Selecting two or more suppliers to meet demands as none of suppliers can individually meet all buyers' requirements (multiple sourcing). In such situation, we face order allocation problem where the best suppliers should be selected and the optimal order quantities should be assigned to each of them (Nazari-Shirkouhi *et al.,* 2013).

Another characteristic of supplier selection is that using qualitative criteria of decision making that is affected by uncertainty mainly due to the vagueness intrinsic to evaluation of qualitative criteria, as well as imprecise weighing of different criteria by different decision makers. Fuzzy set theory has been the most important approach used to deal with uncertainty in the supplier selection decision process. It provides proper language by which imprecise criterion can be handled and it is able to integrate the analysis of qualitative and quantitative factors in the selection process. To meet practical decision-making requirements and dominance of vagueness intrinsic, the proposed fuzzy analytic hierarchical process (FAHP) is used to ranking the alternative. In this proposed method we preserved the uncertainty to the last stage because while the decisions are closely, eliminate uncertainty sometime can lead to the wrong decision.

Hsu *et al.,* (2010) used the Fuzzy AHP in lubricant regenerative technology selection, Kar *et al.,* (2011) used FAHP to vendor selection, Chan and Kumar (2007) used the FAHP to supplier selection considering risk factors, Kharaman *et al.,* (2003) used FAHP to supplier selection.

Kannan *et al.,* (2013) used integrated fuzzy multi criteria decision making method and multi-objective programming approach for supplier selection and order allocation in a green supply chain. Nazari-Shirkouhi *et al.,* (2013) used a two-phase fuzzy multi-objective linear programming to Supplier selection and order allocation. Ustun and Demirtas (2008) integrate ANP and multi-period, multi-objective mixed integer linear programming (MOMILP) for choosing the best suppliers and define the optimum quantities among the selected suppliers. Lin (2009) used an integrated FANP–MOLP for supplier evaluation and order allocation.

Lin (2012) for supplier evaluation and order allocation used integrated FANP–MOLP. In the integrated models has been used in literature. The final weights of multi-criteria decision-making methods are used is real numbers that obtained from solve. So, in this paper we have tried to keep the ambiguity of pair-wise comparisons to the final step that has been neglected in studies.

In this paper to solve the problem, calculation is divided into two parts FAHP and FMLOP that in part one to determine the weight of alternative we proposed FAHP method that keeps the uncertain until the last stage. And then used fuzzy weight to MOLP model. The paper is organized as follows: In Section 2, background information include fuzzy theory and fuzzy numbers, Analytic Hierarchy Process (AHP) method, Linear programming model with the fuzzy objective function coefficients, and step method (STEM) is present. In Section 4, the propose method**,** In Section 5 case study and the section 6 conclusion is present.

Background Information

The Fuzzy Theory and Fuzzy Numbers

As indicated that human judgment about preferences are often Unclear to estimate by exact numerical values, again fuzzy logic is useful for handling problems characterized by vagueness and imprecision. The fuzzy set theory introduced by Zadeh (1965) to incorporate the uncertainty of human thoughts in modelling. The most critical contribution of fuzzy set theory is its capability of representing imprecise or vague data. A symbol that represents a fuzzy set receives a tilde " $\sim$ " above it. A triangular fuzzy number (TFN) is shown in Figure. 1.

- For addition of a fuzzy number $M_1 = (a_1, b_1, c_1)$ and $M_2 = (a_2, b_2, c_2)$ are apply the $\oplus$ symbol

$$M_1 + M_2 = (a_1, b_1, c_1) \oplus (a_2, b_2, c_2) = (a_1 + a_2, b_1 + b_2, c_1 + c_2)$$

- Multiplication of a fuzzy number $M_1 = (a_1, b_1, c_1)$ and $M_2 = (a_2, b_2, c_2)$ are apply the $\otimes$ symbol

$$M_1 \times M_2 = (a_1, b_1, c_1) \otimes (a_2, b_2, c_2) = (a_1 \times a_2, b_1 \times b_2, c_1 \times c_2)$$

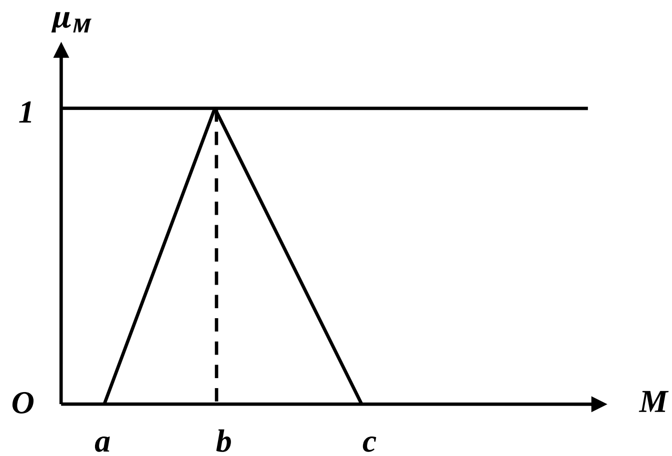

Figure 1: Triangular Fuzzy Number (TFN)

The Analytic Hierarchy Process (AHP) Method

*A*HP is suggested based on the human brain to analyze complex issues and the phase. Methods have been proposed by Saaty (1980,1999), since so many applications for this approach is discussed. AHP and its application is based on three principles:

- Establishing a hierarchical structure and format for problem Figure.2
- Establish preferences by pair-wise comparisons (form marginal rate of substitution) Table 1, 2.
- Establish the logical consistency of measurements

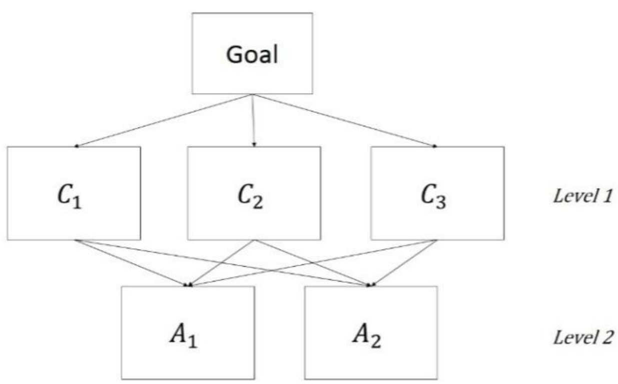

Figure 2: Hierarchical Structure and Format

To calculate the final weight options, will be form pair-wise comparisons matrices and matrices for each level and multiplying them from the lowest to the highest level.

Table 1: Pairwise Comparisons of Criteria

	C_1	C_2	C_3	W_{goal}Weight
C_1	1	$\tilde{w}_{12}$	$\tilde{w}_{13}$	$\widetilde{W}_{1goal}$
C_2	$\tilde{w}_{21}$	1	$\tilde{w}_{23}$	$\widetilde{W}_{2goal}$
C_3	$\tilde{w}_{31}$	$\tilde{w}_{32}$	1	$\widetilde{W}_{3goal}$

Table 2: Weight of Alternative Relate to each Criteria

	$W_{criteria}$		
	C_1	C_2	C_3
A_1	$\widetilde{W}_{1C_1}$	$\widetilde{W}_{1C_2}$	$\widetilde{W}_{1C_3}$
A_2	$\widetilde{W}_{2C_1}$	$\widetilde{W}_{2C_2}$	$\widetilde{W}_{2C_3}$

$$weight\ of\ alternative_{\ 2\times1} = W_{criteria_{2\times3}} \times W_{goal_{3\times1}}$$

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Fuzzy Linear Programming Model

Fuzzy linear programming was proposed by Zimmermann (1978). Fuzzy linear programming consists of fuzzy goals, and fuzzy constraints can be reformulated in such a way that it can be solved like a normal linear programming problem. Conventional LP problem proposed by Zimmermann (1978) is given below:

$$Max\ CX$$
$$s.t\ :\mathrm{A}\,X \le b$$
$$X \ge 0$$

After fuzzification, the equation can be represented like this

$$Max\ \tilde{C}X$$
$$s.t\ :\tilde{\mathrm{A}}\,X \lesssim \tilde{b}$$
$$X \ge 0$$

The symbol $\lesssim$ in the constraint set denotes 'essentially smaller than or equal to' and allows one reach some aspiration level where: $\tilde{C}$ and $\tilde{A}$ represent the fuzzy values. For example suppose that the objective function coefficients are triangular fuzzy numbers. The fuzzy vector $\tilde{C}$ is defined as follows: $\tilde{C} = \left(C^l, C^m, C^u\right)$

Fuzzy linear programming model is converted into the following form:

$$MAX\ \ Z = \sum_{j=1}^{n}\left(C^l, C^m, C^u\right)X_j$$
$$s.t$$
$$\sum_{j=1}^{n} a_{ij}x_j \le b_i \qquad i = 1, 2, \ldots, m$$
$$x_j \ge 0 \qquad \forall j$$

Maximize the values of the right and middle, and minimize the left triangular fuzzy numbers, the problem with this approach is become a multi-objective linear programming problem in the certain case is as follows:

$$\mathrm{MIN}\ \ Z_1 = \left(C^m - C^l\right)X$$
$$MAX\ \ Z_2 = C^m X$$
$$MAX\ \ Z_3 = \left(C^u - C^m\right)X$$
$$s.t$$
$$AX \ge 0$$
$$X \ge 0$$

Step Method (STEM)

The improved STEM method presented by Izadikhah & Alikhani (2012) that the steps are as follows:

i. Identify the weight vector of objectives. The method requires that the DM gives a vector of weight W relating the objectives. W is generally normalized so that $\sum_{i=1}^{k} W_i = 1$ and the bigger weighting coefficient is associated with the more important objectives.

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ii. Construct the pay-off table. In this step we first maximize each objective function and construct a pay-off table to obtain the positive ideal criterion

Vector $f^{+} \in R^{K}$.

Let f^{+} ,j = 1,...,k, be the solutions of the following k problems, namely, positive ideal solution:

$$f^{+} = MAX\ f_j(x)$$
$$s.t$$
$$x \in s$$

Table 3: Pay-Off Table

	f_1	f_2	$\cdots$	f_j	$\cdots$	f_k
f_1	f_1^{+}	f_{21}	$\cdots$	f_{1j}	$\cdots$	f_{k1}
f_2	f_{12}	f_2^{+}	$\cdots$	f_{j2}	$\cdot\cdot$	f_{k2}
			$\cdots$			
$\vdots$	$\vdots$				$\vdots$	
f_j	f_{1j}	f_{2j}	$\cdots$	f_j^{+}	$\cdots$	f_{kj}
f_k	f_{1k}	f_{2k}	$\cdots$	f_{jk}	$\cdots$	f_k^{+}

The pay-off table is of the form Table 3.

In Table 3, row j corresponds to the solution vector x^{j+} which maximizes the objective function f_j . A f_{ij} is the value taken by the ith objective f_i when the jth objective function $f_j$reaches its maximumf_j^{+}, that is, $f_{ij} = f_j(x^{j+})$.

Then the positive ideal criterion can be define as follows:

$$f^{+} = (f_1^{+},..., f_k^{+}) = (f_1(x^{1+}),..., f_k(x^{k+}))$$

And consider that x^{+} be the inverse image of f^{+}. Generally, we know it is may be x^{+} not belong to $S^{(h)}$.

iii. Calculate the weight factors.

Let f_i^{min} be the minimum value in the ith column of the first pay-off table (Table 3).

Calculate $\pi_i$values where:

$$\pi_i = \begin{cases} \dfrac{f_i^{+} - f_i^{min}}{f_i^{+}} \left[\dfrac{1}{\sqrt{\sum_{i=1}^{n} (Cji)^2}} \right] & f_i^{+} > 0 \\ \dfrac{f_i^{min} - f_i^{+}}{f_i^{min}} \left[\dfrac{1}{\sqrt{\sum_{i=1}^{n} (Cji)^2}} \right] & f_i^{+} < 0 \end{cases}$$

Where C_{ij} are the coefficients of the ith objective. Then, the weighting factors can be calculated as follows:

$\beta_i = \frac{\pi_i}{\sum_{i=1}^{k}\pi_i}$ The weighting factors defined as above are normalized, that is they satisfy the following conditions:

$$0 \le \beta_i \le 1 \ , \ i = 1,\ldots,k \quad and \ \sum_{i=1}^{k}\beta_i = 1$$

The weights defined above reflect the impact of the differences of the objective values on decision analysis. If the value $(f_i^+ - f_i^{min})$ is relatively small, then the objective $f_i(x)$ will be relatively insensitive to the changes of solution x. In other words, $f_i(x)$ will not play an important role in determining the best compromise solution.

iv. Calculation Phase.

The weight factors defined by formula 8 are used to apply the weighted Tchebycheff metric ,Def. 2.2, to obtain a compromise solution, Also, the weight vector of objectives are used to emphasize that more important objectives be more closer to ideal one. We can obtain a criterion vector which is closest to positive ideal one and emphasize that more important objectives be more closer to ideal one by solve the following model:

$$\begin{aligned} & min \ \alpha \\ & s.t. \\ & \quad W\left(f^+ - f(x)\right)_\infty^\beta \le \alpha \\ & \quad x \in S^{(h)} \\ & 0 \le \alpha \in R \end{aligned}$$

This model can be converted to the following model:

$$\begin{aligned} & min \ \alpha \\ & s.t. \\ & \quad W_i\beta_i\left(f^+ - f(x)\right) \le \alpha \quad 1 \le i \le k \\ & \quad x \in S^{(h)} \\ & 0 \le \alpha \in R \end{aligned}$$

We solve the weighted minimax model 11 and obtain the solution $x^{(h)}$By solving the model 11 we obtain a compromise solution as $x^{(h)}$. In the other words, we obtain a compromise solution $x^{(h)}$in the reduced feasible region $S^{(h)}$whose criterion vector is closest to positive ideal criterion vector f^+.

v. (Decision phase)

The compromise solution $x^{(h)}$ is presented to the decision maker, who compares objective vector $f(x^{(h)})$ with the positive ideal criterion vector f^+This decision phase has the following steps:

- **V.i**: If all components of $f(x^{(h)})$ are satisfactory, stop with $(x^{(h)}, f(x^{(h)}))$ as the final solution and $x^{(h)}$is the best compromise solution. Otherwise go to step 5.2.
- **V,ii**: If all component of $f(x^{(h)})$ are not satisfactory, then terminate the interactive process and use other method to search for the best compromise solutions. Otherwise go to step 5.3.
- **V,iii**: If some components of f(x(h)) are satisfactory and others are not, the DM must relax a objective fj(x) to allow an improvement of the unsatisfactory objectives in the next iteration. If the decision maker cannot find an objective to sacrifice, then the interactive process will be terminated and other method have to be used for identifying the best compromise solution, otherwise, the DM gives fj as

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the amount of acceptable relaxation. fj is the maximum amount of fj(x) we are willing to sacrifice. Now go to step 5.4.

- **V,iV**: Define a new reduced feasible region as:

$$S^{(h+1)} = \left\{ x \in S^{(h)} \;\middle|\; \begin{array}{ll} f_j(x) \geq f_j\left(x^{(h)}\right) - \Delta f_j & \\ f_i(x) \geq f_i\left(x^{(h)}\right) & i = j \;,\; i = 1, \ldots, k \end{array} \right.$$

And the weights π_j are set to zero. set $h = h + 1$ and go to step 3.

Proposed Method

In this paper we intend to evaluate the suppliers and then allocate optimum order quantities to suppliers . Therefore, follow 8 steps to achieve the optimal order quantity.

Step 1. According to a survey of experts, the key factors in selecting a supplier is identified, and then form the hierarchical structure model.

Step 2. Form the pair-wise Comparisons like Table 4.

Table 4: Pairwise Comparisons

	C_1	C_2	…	C_k
C_1	1	$\widetilde{w_{12}}$	…	$\widetilde{w_{1k}}$
C_2	$\widetilde{w_{21}}$	1	…	$\widetilde{w_{2k}}$
⋮	⋮	⋮	⋮	⋮
C_k	$\widetilde{w_{k1}}$	$\widetilde{w_{k2}}$	…	1

Step 3. Calculate fuzzy weight vector for all paired comparisons matrixes that each element calculate by

$$S_i = \sum_{j=1}^{k} w_{ij} \times \left[\sum_{i=1}^{k} \sum_{j=1}^{k} w_{ij} \right]^{-1}$$ where $\widetilde{S_i}$ denote the weight of factor i.

Step 4. Form the Preference matrix to each level Similar usual AHP method with the difference that weights are fuzzy and call W^i.

Step 5. Multiply the Preference matrix $(W^k \times W^{k-1} \times \ldots \times W^2 \times W^1)$.

Step 6. After computing will be shaped triangular fuzzy vector alternatives. Determine the gained final vector of triangular fuzzy for alternatives, as the coefficients of the objective function to the order quantity.

Step 7. Form the fuzzy MOLP

The notation list of model is proposed in Table 5.

The FMOLP model with six objective, *n* decision variables and n+1 constraints are formulated as follows:

$$Min\, z_1 = \sum_{i=1}^{n} \alpha_i o_i \qquad (objective\, defect)$$

$$Min\, z_2 = \sum_{i=1}^{n} \beta_i o_i \qquad (objective\, delay)$$

$$Min\, z_3 = \sum_{i=1}^{n} \gamma_i o_i \qquad (objective\, purchasing\, cost)$$

$$Min\, z_4 = \sum_{i=1}^{n} \delta_i o_i \qquad (objective\ return\ cost)$$

$$Min\, z_5 = \sum_{i=1}^{n} \theta_i o_i \qquad (objective\ transportation\ cost)$$

$$Min\, z_6 = \sum_{i=1}^{n} \tilde{w}_i o_i \qquad (objective\ overall\ fuzzy\ weight)$$

S.t

$$B_1 \le \sum_{i=1}^{n} O_i \le B_2 \qquad (total\ order\ quantity\ constraint)$$

$$O_i \le b_i \quad i = 1, 2, \ldots, n \qquad (suppliers\ order\ quantity\ constraint)$$

According to expert opinion the constraint consider as crisp value.

Table 5: Definition of Variables

Variable	Definition of Variable
O_i	The order quantity of supplier i
α_i	The defect ratio of supplier i
β_i	The delay ratio of supplier i
γ_i	The purchasing cost ratio of supplier i
δ_i	The return cost ratio of supplier i
θ_i	The transportation cost ratio of supplier i
$\tilde{w}_i$	The overall fuzzy weight of supplier i(output of fuzzy AHP)
B_1	The lower bound of total order
B_2	The upper bound of total order
b_i	The upper bound of O_iType equation here.

Step 8. Solve the FMLOP by STEM method

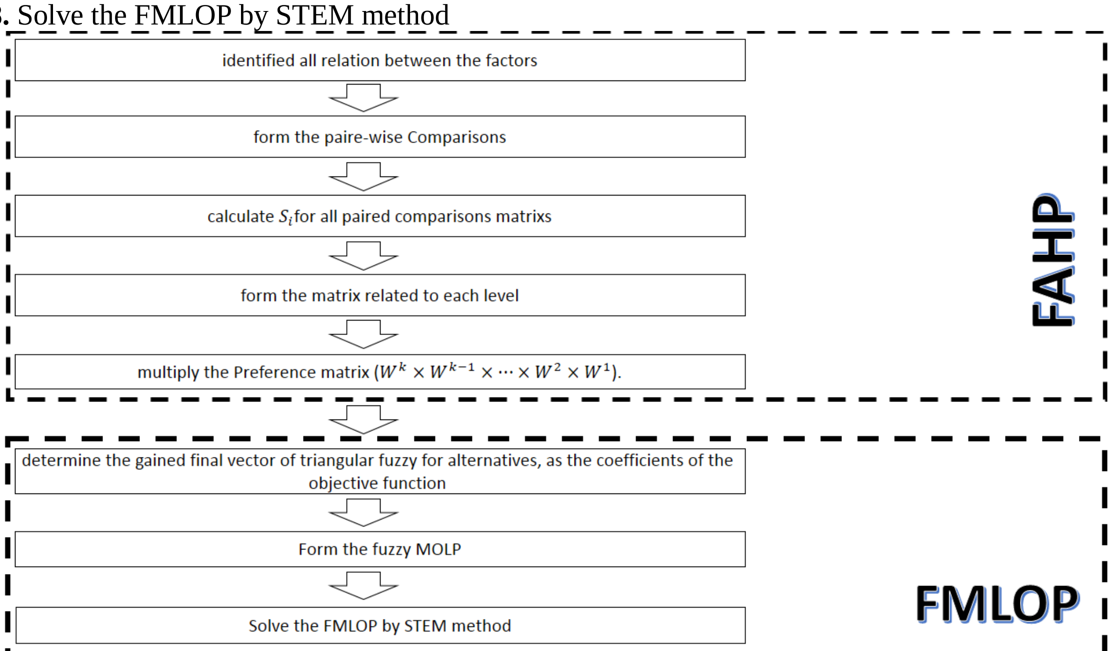

Figure 3: The Structure of the Problem

Research Article

Case Study

In this paper a case study for sporting goods manufacturing company in Iran-Tehran has been presents. This company produces the good for sports such as boxing, Taekwondo, Karate etc. The company has decided to selecting supplier(s) for part of its raw materials between candidate alternatives**.** It should be noted that the unit cost of transportation, the cost of returning a product and Price are not equal.

Table 6: Quantity of Variables

	O_1	O_2	O_3	O_4	O_5	$\sum_i O_i$
α_i	0.001	0.0002	0.0018	0.0018	0.0018	
β_i	0.2	0.27	0.19	0.18	0.23	
γ_i	0.43	0.425	0.3	0.4	0.35	
δ_i	0.23	0.218	0.18	0.21	0.235	
θ_i	0.28	0.223	0.23	0.26	0.4	
b_i	15,000	13,000	14,000	10,000	17,000	
B_1						30,000
B_2						35,000

MIN $0.001O_1 + 0.0002O_2 + 0.0018O_3 + 0.0018O_4 + 0.0018O_5$ Defect
MIN $0.2O_1 + 0.27O_2 + 0.19O_3 + 0.18O_4 + 0.23O_5$ Delay
MIN $0.43O_1 + 0.425O_2 + 0.3O_3 + 0.4O_4 + 0.35O_5$ Price
MIN $0.28O_1 + 0.223O_2 + 0.23O_3 + 0.26O_4 + 0.4O_5$ The cost of returning a product
MIN $0.23O_1 + 0.218O_2 + 0.18O_3 + 0.21O_4 + 0.235O_5$ Transportation Coast
MAX $\sum_i \widetilde{W_O} O_i$ Order
S.T

$$30000 \leq O_1 + O_2 + O_3 + O_4 + O_5 \leq 35000$$

$O_1 \leq 15000$
$O_2 \leq 13000$
$O_3 \leq 14000$
$O_4 \leq 10000$
$O_5 \leq 17000$

Scale of fuzzy pairwise comparisons shown in Table 7 and the related factors form hierarchical structure shown in Figure 3 that illustrates the relationship between these factors.

Table 7: Linguistic Scale for Relative Importance

1.	Equal importance(E)	(1,1,1)
2.	Very low (VL)	(1,1,3)
3.	Low (L)	(1,3,5)
4.	Average (A)	(3,5,7)
5.	High (H)	(5,7,9)
6.	Very High (VH)	(7,9,11)

Step 1: The experts of company presented the supply selection criteria and alternatives that consist of 5 alternative and 7 criteria including defect, adherence to contract, flexibility, transportation coast, price, delivery and quality as shown in Figure 3.

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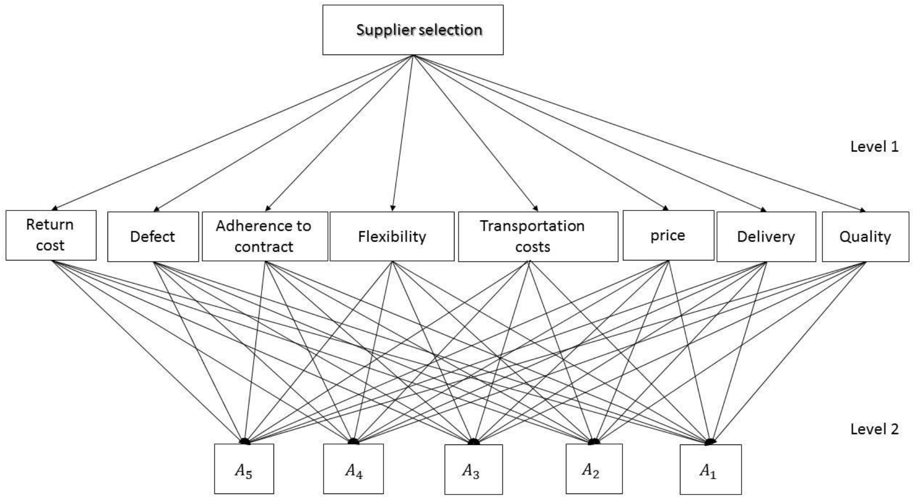

Figure 3: The Hierarchical Structure Model

Table 8: Fuzzy Pairwise Comparisons Table of Criteria with Criteria Weight W^1

	Q	D	P	TC	F	AC	DE	W^1
Q	1	$\tilde{3}$	$1/\tilde{2}$	$\tilde{4}$	$\tilde{2}$	$\tilde{1}$	$\tilde{5}$	(0.1082,0.2435,0.5285)
D	$1/\tilde{3}$	1	$1/\tilde{3}$	$\tilde{3}$	$\tilde{1}$	$1/\tilde{4}$	$1/\tilde{2}$	(0.0263,0.0737,0.1664)
P	$\tilde{2}$	$\tilde{3}$	1	$\tilde{2}$	$\tilde{3}$	$\tilde{1}$	$\tilde{2}$	(0.0749,0.1686,0.4404)
TC	$1/\tilde{4}$	$1/\tilde{3}$	$1/\tilde{2}$	1	$\tilde{2}$	$\tilde{3}$	$1/\tilde{3}$	*(0.0263,0.0737,0.1957)*
F	$1/\tilde{2}$	$\tilde{1}$	$1/\tilde{3}$	$1/\tilde{2}$	1	$1/\tilde{2}$	$1/\tilde{3}$	(0.0399,0.0999,0.2055)
AC	$\tilde{1}$	$\tilde{4}$	$\tilde{1}$	$1/\tilde{3}$	$\tilde{2}$	1	$\tilde{2}$	(0.0824,0.1624,0.3817)
DE	$1/\tilde{5}$	$\tilde{2}$	$1/\tilde{2}$	$\tilde{3}$	$\tilde{3}$	$1/\tilde{2}$	1	(0.0487,0.1424,0.3426)

For level 2, form the all pairwise comparisons and after calculating fuzzy weight vector similar to Table 8, this weights inters in Table 9.

Table 9: Decision Matrix for Level 2 (W^2)

	O_1	O_2	O_3	O_4	O_5
Q	(0.044,0.138,0.344)	(0.098,0.178,0.367)	(0.146,0.314,0.650)	(0.084,0.156,0.303)	(0.097,0.212,0.457)
D	(0.058,0.293,0.481)	(0.043,0.129,0.235)	(0.120,0.346,0.537)	(0.120,0.346,0.537)	(0.0583,0.151,0.254)
P	(0.298,0.079,0.141)	(0.043,0.129,0.235)	(0.120,0.346,0.537)	(0.0583,0.151,0.254)	(0.058,0.293,0.481)
TC	(0.023,0.153,0.368)	(0.045,0.155,0.463)	(0.230,0.368.0.645)	(0.111,0.264,0.559)	(0.059,0.134,0.274)
F	(0.176,0.33,0.645)	(0.111,0.264,0.559)	(0.074,0.199,0.559)	(0.038,0.073,0.158)	(0.059,0.134,0.274)
AC	(0.079,0.136,0.238)	(0.205,0.336,0.530)	(0.121,0.213,0.353)	(0.082,0.132,0.253)	(0.107,0.183,0.307)
DE	(0.097,0.353,0.098)	(0.069,0.258,0.836)	(0.029,0.063,0.209)	(0.072,0.213,0.679)	(0.043,0.113,0.418)

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Step 2, 3, 4: Form the comparisons matrix and calculate fuzzy weight vector (Table 8) for all paired comparisons matrixes that each element of this vector denote the $\widetilde{S_i}$. Then form the Preference matrix for level 1 and level 2 (Table 8, Table 9).

Step 5: In this step to gaining the alternative weight, multiplies Preference matrix of each level

$$Alternative\ fuzzy\ weight = W^2 \times W^1 = \begin{bmatrix} (0.0488, 0.1942, 0.695) \\ (0.0421, 0.2109, 1.0811) \\ (0.0499, 0.2603, 1.1869) \\ (0.0329, 0.1754, 0.8838) \\ (0.0317, 0.1861, 0.8893) \end{bmatrix}$$

Step 6, 7:

In this step, the alternatives weight combine with MLOP and for solving it the STEM method is used.

Min φ

s.t

$$\varphi \geq (-21.2 - (-0.001O_1 - 0.0002O_2 - 0.0018O_3 - 0.0018O_4 - 0.0018O_5)) \times 0.985$$
$$\varphi \geq (-5760 - (-0.2O_1 - 0.27O_2 - 0.19O_3 - 0.18O_4 - 0.23O_5)) \times 0.0018$$
$$\varphi \geq (-9800 - (-0.43O_1 - 0.425O_2 - 0.3O_3 - 0.4O_4 - 0.35O_5)) \times 0.0015$$
$$\varphi \geq (-5928 - (-0.23O_1 - 0.218O_2 - 0.18O_3 - 0.21O_4 - 0.235O_5)) \times 0.002$$
$$\varphi \geq (-6839 - (-0.28O_1 - 0.223O_2 - 0.23O_3 - 0.26O_4 - 0.24O_5)) \times 0.000001$$
$$\varphi \geq (-4349 - (-0.1435O_1 - 0.1688O_2 - 0.2104O_3 - 0.1425O_4 - 0.1544O_5)) \times 0.00002$$
$$\varphi \geq (7924.3 - (0.1923O_1 + 0.2109O_2 + 0.2603O_3 + 0.1754O_4 + 0.1861O_5)) \times 0.003$$
$$\varphi \geq (29952.2 - (0.5027O_1 + 0.8702O_2 + 0.9266O_3 + 0.7084O_4 + 0.7032O_5)) \times 0.0012$$
$$30000 \leq O_1 + O_2 + O_3 + O_4 + O_5 \leq 35000$$

$O_1 \leq 15000$
$O_2 \leq 13000$
$O_3 \leq 14000$
$O_4 \leq 10000$
$O_5 \leq 17000$

Step 8:

Finally, after solving the FMLOP model, the allocation value to each supplier obtained and presented in Table 10.

Table 10: The Allocation Value Obtain from Solving FMLOP Model

Supplier	**Supplier Order Quantity**
O_1	6463.471
O_2	13000
O_3	10556.529
O_4	0
O_5	0

Results obtained from solving FMLOP indicate, for allocating raw materials of company we should support from O_1, O_2 and O_3 suppliers.

Conclusion

Supplier selection process is a complicated task. Establishing long-term relationships with a small number of suppliers is an important part of supply chain management. Therefore, supplier selection is a crucial strategic decision for long term survival of the firm. In the present supplier selection model, a combined approach of fuzzy-AHP and fuzzy multi-objective linear programming are used. In this model fuzzy AHP

is used first to calculate the weights of the criteria and then fuzzy linear programming is used to find out the optimum solution of the problem.
Furthermore, in this work, instead of defuzzification the weight of alternative in AHP model, the fuzzy characteristic preserve and applied in MLOP model. On the other hand, this proposed approach can be used for any researcher and practitioner in different fields, who need a reliable tool to evaluate a set of alternatives in terms of evaluation criteria which can be determined based on what kind of the problem is deal with.
In this study, the proposed methodology was also applied for a company to evaluate the alternatives and optimal allocation of order.

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