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# A Model for Suppliers' Assessment through fuzzy AHP Technique at Piece Making Firms

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## Abstract

*This research indicates a model for choosing the suppliers in IDEM factory. The statistical samples in criteria-selecting stage were 92 people who were selected spontaneously, and also there were 8 people of the senior managers from each part in the ranking stage. In the first step it was specified by Cronbach α and in the second step by the inconsistency coefficient of reliability of the questionnaires. In the next step the criteria was specified by biniminal test calculations, and finally we paid to classify them by FAHP which according to the obtained results, the quality criterion with 0.135 weights has the most important. The green production criterion with 0.131 weights is in the second priority. The geographical location criterion with minimum weight (0.075) is in the last priority. For testing this model, five suppliers were ranked; so we have: the first ranking is for the fourth supplier with 0.332 weights. The fifth ranking is for the sixth supplier with 0.133 weights.*

**Keywords**: The supplier selecting criteria, supplier, Prioritize, FAHP.

## Introduction

In most industries, the cost of raw materials and the components include the mass part of the completed cost of the product, of course the logistics sector can play a key role in the efficiency and effectiveness of an organization and influence directly on reducing the costs, benefit and flexibility of a company[1]. Managing the supplying continuum and suppliers selecting process are so important in the management literatures. In 1990's, most of the factories were looking for cooperating with suppliers to improve the management operation and their competitiveness. The relation between suppliers and customers were considered in production companies[2]. Several techniques for supplier selection have been proposed. The first group is Mathematical programming models are used. For example data envelopment analysis[3], a fuzzy mixed integer goal programming[4] and a mixed integer non-linear programming[5]. The second is linear weighting models used in Analytic hierarchy process[6]and interpretive structural modeling[7]. This research indicates an FAHP model for choosing the suppliers in IDEM factory.

**Criteria selection:** In a research conducted by Choi and Hatly[8]on America automobile industry, eight major criteria for supplier selection identified. These criteria include: financial resources, stability, relationships, flexibility, technological capability, customer service, reliability, and price. Several authors on this subject suggest a variety of factors to be taken into account[9,10]. Ellram[11] suggested a hierarchy framework including financial, performance, technology, organizational culture and strategy, and other factors. Some of the mathematical programming models[12-15] focus on the modelling of speci"c discounting environments. Weber *et al*[16] selected price, delivery, quality, facilities and capacity, geographic location, technology capability. Ghodsypour and O'Brin[17] stated that cost, quality and service are very effective in supplier selection parameters. Dickson[18] identified 23 different criteria. The most important ones were quality, delivery, performance history, warrant and claim policy, production facilities and capacity, net price, and technical capability. Wang[19] concluded that there is no evidence that selecting suppliers based on price has a positive impact on firm performance. Kahraman *et al*[20] introduced four groups of criteria: supplier criteria, product performance criteria, service performance criteria and cost criteria.

## Methodology

Identifying the supplier selection criteria and their identification. The supplier selection criteria were extracted by the studied researches and librarian methods. And these criteria were investigated by attention to the statistical society, the suitable selective variables and their acceptance as supplier selection criteria. The supplier selection criteria are; management and organizing, reliability, the product quality, cost, technical ability, customer, product warranties, technical support, green products, financial stability, geographic location.

A questionnaire which included the independent questions and Likert type was used for identifying the criteria.

**Table-1**
**The Likert options**

| Options | Totally Disagree | Disagree | Agree somewhat | Agree | Totally Agree |
|---|---|---|---|---|---|
| Ranking | 1 | 2 | 3 | 4 | 5 |

To identify the validity, the questionnaire was given to some Marketing professors and Students in Doctor of Business Administration – Marketing, and after doing some suggested corrections, the final questionnaire was codified. For final evaluation the *cronbach's alpha* method and *SPSS software* were used.

$$\propto = \left(\frac{k}{k-1}\right)\left(\frac{s_y^2 - \sum s_i^2}{s_y^2}\right)$$

Which in it: K: the number of subparts of the questions of the questionnaire or test, $s_i^2$: The variances under the test I, $s_y^2$ : The variance of the whole questionnaire or test,

**The Reliability of the test's results:** The questionnaire is given to 30 persons of the middle and senior managers, and its *cronbach α* was computed and calculated, because all coefficients and the total coefficient were more than 0.6, so the questionnaire has the acceptable durability.

**Table-2**
**The total number of the alpha coefficient resulted from the total questionnaire**

| α coefficient | number of the Criteria |
|---|---|
| 0.75 | 11 |

By *Komologrov- Esmirnov test*, we attend to study the normality and abnormality of the data. In this test the null hypothesis is based on the normal distribution. While if the significance level is smaller than 0.05, the studying variables will be abnormal.

**Table-3**
**The cronbach α coefficient for each of the criteria**

| Criteria | cronbach α coefficient |
|---|---|
| management and organizing | 0.728 |
| Reliability | 0.743 |
| the product quality | 0.745 |
| Cost | 0.724 |
| technical ability | 0.71 |
| Customer | 0.722 |
| product warranties | 0.758 |
| technical support | 0.74 |
| green products | 0.714 |
| financial stability | 0.733 |
| geographic location | 0.735 |

The results show that data are distributed abnormally; and for testing the hypotheses, the nonparametric tests were used, and so the *Binomial Test* was used.

The results of the *Binomial test* show that all criteria were accepted except the technical support and financial stability, because the comments' number of <=3 were more than the comments' number of >3. To test, the supplier's model 5 was ranked and the conceptual model of the research was obtained.

**Table-4**
**The Esmirnov- Komologrov Test**

| Criteria | N | Mean | Std. Deviation | Absolute | Positive e | Negative e | Kolmogoro v-Smirnov Z | Asymp. Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
| Managing and organizing | 92 | 3.65 | .966 | .282 | .185 | -.282 | 2.704 | .000 |
| Reliability | 92 | 3.78 | .849 | .340 | .258 | -.340 | 3.262 | .000 |
| Product quality | 92 | 3.61 | 1.048 | .298 | .191 | -.298 | 2.856 | .000 |
| Cost | 92 | 3.93 | .862 | .280 | .220 | -.280 | 2.687 | .000 |
| Technical ability | 92 | 3.77 | .950 | .225 | .161 | -.225 | 2.161 | .000 |
| Customer | 92 | 3.98 | .798 | .250 | .217 | -.250 | 2.398 | .000 |
| Product warranties | 92 | 3.55 | .894 | .310 | .211 | -.310 | 2.978 | .000 |
| Technical support | 92 | 2.93 | 1.003 | .243 | .213 | -.243 | 2.334 | .000 |
| Green product | 92 | 4.01 | .943 | .289 | .189 | -.289 | 2.771 | .000 |
| Financial stability | 92 | 2.77 | .973 | .234 | .233 | -.234 | 2.245 | .000 |
| Geographic location | 92 | 3.71 | .884 | .250 | .196 | -.250 | 2.395 | .000 |

**Table-5**
**Binomial Test**

| | | Category | N | Observed Prop. | Test Prop. | Asymp. Sig. (2-tailed) |
|---|---|---|---|---|---|---|
| Managing and organizing | Group 1 | <= 3 | 33 | .36 | .50 | .009[a] |
| | Group 2 | > 3 | 59 | .64 | | |
| | Total | | 92 | 1.00 | | |
| Reliability | Group 1 | <= 3 | 24 | .26 | .50 | .000[a] |
| | Group 2 | > 3 | 68 | .74 | | |
| | Total | | 92 | 1.00 | | |
| Product quality | Group 1 | <= 3 | 32 | .35 | .50 | .005[a] |
| | Group 2 | > 3 | 60 | .65 | | |
| | Total | | 92 | 1.00 | | |
| Cost | Group 1 | <= 3 | 23 | .25 | .50 | .000[a] |
| | Group 2 | > 3 | 69 | .75 | | |
| | Total | | 92 | 1.00 | | |
| Technical ability | Group 1 | <= 3 | 34 | .37 | .50 | .016[a] |
| | Group 2 | > 3 | 58 | .63 | | |
| | Total | | 92 | 1.00 | | |
| Customer | Group 1 | <= 3 | 24 | .26 | .50 | .000[a] |
| | Group 2 | > 3 | 68 | .74 | | |
| | Total | | 92 | 1.00 | | |
| Product warranties | Group 1 | <= 3 | 35 | .38 | .50 | .028[a] |
| | Group 2 | > 3 | 57 | .62 | | |
| | Total | | 92 | 1.00 | | |
| Technical support | Group 1 | <= 3 | 68 | .74 | .50 | .000[a] |
| | Group 2 | > 3 | 24 | .26 | | |
| | Total | | 92 | 1.00 | | |
| Green product | Group 1 | <= 3 | 19 | .21 | .50 | .000[a] |
| | Group 2 | > 3 | 73 | .79 | | |
| | Total | | 92 | 1.00 | | |
| Financial stability | Group 1 | <= 3 | 76 | .83 | .50 | .000[a] |
| | Group 2 | > 3 | 16 | .17 | | |
| | Total | | 92 | 1.00 | | |
| Geographic location | Group 1 | <= 3 | 35 | .38 | .50 | .028[a] |
| | Group 2 | > 3 | 57 | .62 | | |
| | Total | | 92 | 1.00 | | |

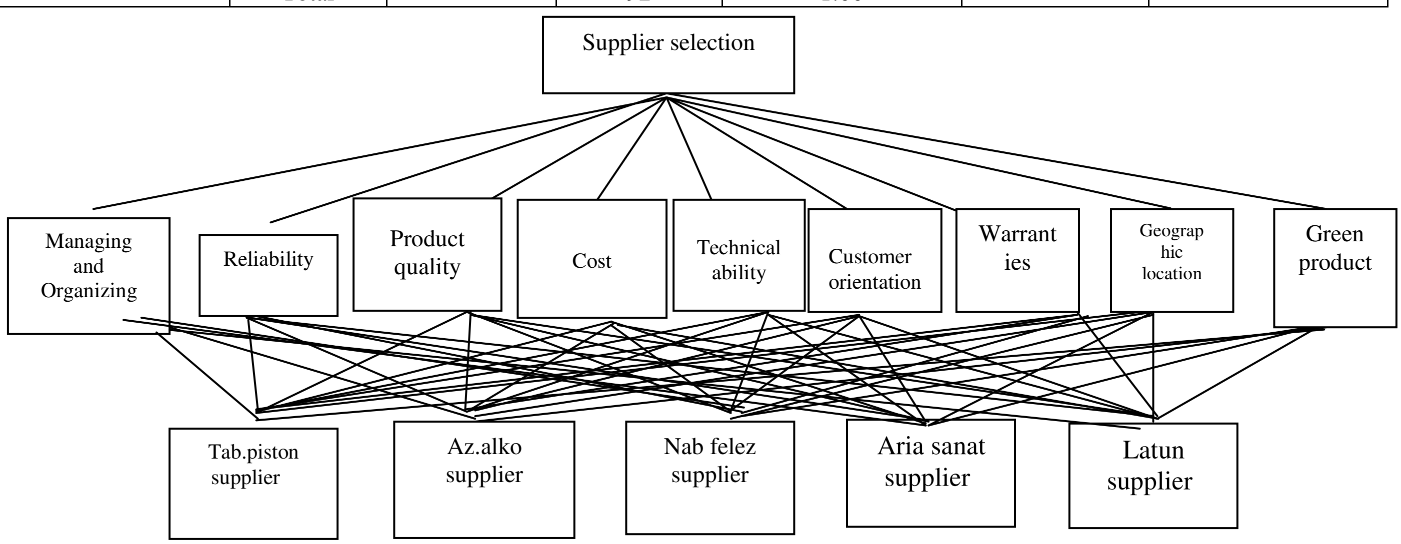


**Figure-1**
**The structure of the supplier selection hierarchy**

The AHP questionnaire and rated Dagrial's research_were used to determine the number of paired comparisons.

**Table-6**
**The number of paired comparisons**

| Verbal phrase | Reveres fuzzy number | triangular fuzzy number |
|---|---|---|
| Exactly the same | (1و1و1) | (1و1و1) |
| Slightly more important | (2/3و1و2) | (1/2و1و3/2) |
| More important | (1/2و2/3و1) | (1و3/2و2) |
| Much more important | (2/5و1/2و2/3) | (3/2و2و5/2) |
| Very Much more important | (1/3و2/5و1/2) | (2و5/2و3) |
| Absolutely important | (2/7و1/3و2/5) | (5/2و3و7/2) |

**The implementation of the method levels:** Designing the hierarchal tree. Forming the paired judgment matrix: the adaptive matrix was decided according to the tree and formed by using the experts through the triangular fuzzy number to the matrix form. Arithmetic mean commitment: the decision makers' arithmetic mean commitment was calculated by matrix.

$$A^{\sim} = \begin{bmatrix} (1,1,1) & a^{\sim}_{12} & a^{\sim}_{12} \\ a^{\sim}_{21} & (1,1,1) & a^{\sim}_{2n} \\ \vdots & \vdots & \vdots \\ a^{\sim}_{n1} & a^{\sim}_{n2} & (1,1,1) \end{bmatrix}$$

$$a^{\sim}_{ij} = \frac{\sum_{1}^{P_{ij}} a_{ijk}}{P_{ij}} \qquad i, j = 1,2, \dots, n$$

Calculating the line's elements' collection:

$$s^{\sim}_{i} = \sum_{j=1}^{n} s^{\sim}_{ij} \qquad i = 1,2, \dots, n$$

Normalizing

$$M^{\sim}_{i} = s^{\sim}_{i} \otimes \left[\sum_{i=1}^{n} s^{\sim}_{i}\right]^{-1} \qquad i = 1,2, \dots, n$$

While the $s^{\sim}_{i}$ is shown according to the $(l_i, m_i, u_u)$, the above relation is calculated according to this order:

$$M^{\sim}_{i} = \left(\frac{l_i}{\sum_{i=1}^{n} u_i}, \frac{m_i}{\sum_{i=1}^{n} m_i}, \frac{u_i}{\sum_{i=1}^{n} l_i}\right)$$

Determining the probability degree of greatness: calculate the probability degree of greatness of every $\mu i$ than the other $\mu i$ s and call it as *d'(Ai)*. So the matrix weight vector is obtained according to this:

W'=(d'(A1),d'(A2), … . d'(An)T

Normalizing: obtain the normalized weights by normalizing the weights' **(w')** vector.

$$W = \left(\frac{d'(A_1)}{\sum_{i=1}^{n} d'(A_i)}, \frac{d'(A_2)}{\sum_{i=1}^{n} d'(A_i)}, \dots, \frac{u_n}{\sum_{i=1}^{n} d'(A_n)}\right)$$

The above weights are the current weights (non-fuzzy).By repeating the process; the whole matrixes' circulation can be obtained.

The weights combination: obtain the final weight of the option by combining the option's weights and criteria[20].

$$U^{\sim}_{i} = \sum_{j=1}^{n} w^{\sim}_{i} r^{\sim}_{ij} \qquad \forall i$$

Calculate the adaptation rate of the matrixes before determining the weight. If the rate is more than 0.1, the matrix is inconsistent[7].

First α=1 section of the decided matrixes and every factor's weight were obtained, and then every row's weight mean was calculated. After that, the obtained weights in column were multiplied to the numbers of the equivalent matrix in line, and the mean of the numbers is the estimate of the n. Then, the adaptation criteria were determined according to this order:

The adaptation criterion $I.I. = \frac{\lambda_{\max} - n}{n - 1}$

The randomness of the criterion is extractable from the table 7 by attending to the numbers of criteria (n):

The rate of inconsistent finally, the rate of the inconsistent is obtained by the formula.

The rate of inconsistent $I.R. = \frac{I.I}{R.I}$

**Table-7**
**Randomness of the criterion (n)**

| N | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $R.I.$ | 0 | 0/58 | 0/9 | 1/12 | 1/24 | 1/32 | 1/41 | 1/45 | 1/49 | 1/51 | 1/48 | 1/56 | 1/57 | 1/59 |

**Table-8**
**α=1 sliced numerals**

| Indexes | Managing and organizing | Reliability | Product quality | Cost | Technical ability | Customer orientation | Product warranties | Geographic location | Green product |
|---|---|---|---|---|---|---|---|---|---|
| Managing and organizing | 1.00 | 1.50 | 0.78 | 1.50 | 0.92 | 1.00 | 0.92 | 1.13 | 0.63 |
| Reliability | 0.71 | 1.00 | 0.79 | 0.92 | 1.13 | 1.38 | 1.04 | 1.54 | 0.68 |
| Product quality | 1.50 | 1.38 | 1.00 | 0.75 | 1.13 | 1.75 | 1.00 | 2.00 | 1.38 |
| Cost | 0.77 | 1.13 | 1.38 | 1.00 | 1.30 | 1.63 | 1.00 | 2.25 | 0.88 |
| Technical ability | 1.13 | 1.00 | 0.92 | 0.92 | 1.00 | 1.88 | 1.00 | 1.13 | 0.92 |
| Customer orientation | 1.00 | 1.17 | 0.58 | 0.67 | 0.96 | 1.06 | 0.75 | 1.38 | 0.71 |
| Product warranties | 1.25 | 1.10 | 1.00 | 1.00 | 1.00 | 1.38 | 1.00 | 1.29 | 0.92 |
| Geographic location | 0.92 | 0.85 | 0.75 | 0.45 | 0.92 | 0.79 | 0.92 | 1.00 | 0.71 |
| Green product | 1.63 | 1.50 | 0.75 | 1.38 | 1.13 | 1.50 | 1.13 | 1.50 | 1.00 |

**Table-9**
**The paired comparative matrix of the main criteria**

| Indexes | Managing and organizing | Reliability | Product quality | Cost | Technical ability | Customer orientation | Product warranties | Geographic location | Green product | Wj |
|---|---|---|---|---|---|---|---|---|---|---|
| Managing and organizing | 0.101 | 0.141 | 0.098 | 0.175 | 0.097 | 0.081 | 0.105 | 0.085 | 0.080 | 0.107 |
| Reliability | 0.072 | 0.094 | 0.099 | 0.107 | 0.119 | 0.112 | 0.119 | 0.116 | 0.087 | 0.103 |
| Product quality | 0.151 | 0.130 | 0.126 | 0.087 | 0.119 | 0.141 | 0.114 | 0.151 | 0.176 | 0.133 |
| Cost | 0.078 | 0.106 | 0.174 | 0.116 | 0.137 | 0.132 | 0.114 | 0.170 | 0.112 | 0.127 |
| Technical ability | 0.114 | 0.094 | 0.116 | 0.107 | 0.105 | 0.152 | 0.114 | 0.085 | 0.117 | 0.112 |
| Customer orientation | 0.101 | 0.110 | 0.073 | 0.078 | 0.101 | 0.086 | 0.086 | 0.104 | 0.091 | 0.092 |
| Product warranties | 0.126 | 0.103 | 0.126 | 0.116 | 0.105 | 0.112 | 0.114 | 0.098 | 0.117 | 0.113 |
| Geographic location | 0.093 | 0.080 | 0.094 | 0.052 | 0.097 | 0.064 | 0.105 | 0.076 | 0.091 | 0.084 |
| Green product | 0.164 | 0.141 | 0.094 | 0.161 | 0.119 | 0.121 | 0.129 | 0.113 | 0.128 | 0.130 |

**Table-10**
**The normalizing matrix (non-scale) and the weight of the main criteria**

| Indexes | Managing | Reliability | Product quality | Cost | Technical ability | Customer orientation | Product warranties | Location | Green product | Wj | D*Wj | DW/Wj |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Managing and organizing | 1.00 | 1.50 | 0.78 | 1.50 | 0.92 | 1.00 | 0.92 | 1.13 | 0.63 | 0.107 | 1.030 | 9.623 |
| Reliability | 0.71 | 1.00 | 0.79 | 0.92 | 1.13 | 1.38 | 1.04 | 1.54 | 0.68 | 0.103 | 0.988 | 9.619 |
| Product quality | 1.50 | 1.38 | 1.00 | 0.75 | 1.13 | 1.75 | 1.00 | 2.00 | 1.38 | 0.133 | 1.278 | 9.610 |
| Cost | 0.77 | 1.13 | 1.38 | 1.00 | 1.30 | 1.63 | 1.00 | 2.25 | 0.88 | 0.127 | 1.220 | 9.633 |
| Technical ability | 1.13 | 1.00 | 0.92 | 0.92 | 1.00 | 1.88 | 1.00 | 1.13 | 0.92 | 0.112 | 1.075 | 9.621 |
| Customer orientation | 1.00 | 1.17 | 0.58 | 0.67 | 0.96 | 1.06 | 0.75 | 1.38 | 0.71 | 0.092 | 0.887 | 9.621 |
| Product warranties | 1.25 | 1.10 | 1.00 | 1.00 | 1.00 | 1.38 | 1.00 | 1.29 | 0.92 | 0.113 | 1.086 | 9.601 |
| Geographic location | 0.92 | 0.85 | 0.75 | 0.45 | 0.92 | 0.79 | 0.92 | 1.00 | 0.71 | 0.084 | 0.798 | 9.556 |
| Green product | 1.63 | 1.50 | 0.75 | 1.38 | 1.13 | 1.50 | 1.13 | 1.50 | 1.00 | 0.130 | 1.251 | 9.613 |

And finally, the rate of the inconsistency of the matrixes was obtained by the below formula.

$$I.R. = \frac{I.I}{R.I}$$

$\lambda_{\max}$ =9.61

$$I.I. = \frac{9.61-9}{9-1} = ./076$$

$$I.R. = \frac{./076}{1/45} = ./052$$

The inconsistency rate is smaller than 0.10, so the consistency of the matrix is acceptable. The inconsistency rate of the other paired comparatives matrixes was calculated like that.

## Results and Discussion

In the paired comparisons of the criteria, the attitudes of the different parts' managers (the financial manager, the manager of purchasing, the manager of fixing part, general manager, the manager of the transportation, the manager of the public relationship, the manager of the quality control, and the manager of R and D) were asked; but in the suppliers comparing part, every table shows the attitudes of the managers of the related criterion.

Now, for example we present the obtained mean matrix of the attitudes by FAHP method.

**Table-11(A)**
**The mean of the numbers of the paired comparisons' criteria's table**

| Indexes | Managing and organizing | | | Reliability | | | Product quality | | | Cost | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Managing and organizing | 1.00 | 1.00 | 1.00 | 1.00 | 1.50 | 2.00 | 0.60 | 0.78 | 1.04 | 1.00 | 1.50 | 2.00 |
| Reliability | 0.52 | 0.71 | 0.80 | 1.00 | 1.00 | 1.00 | 0.60 | 0.79 | 1.04 | 0.79 | 0.92 | 1.30 |
| Product quality | 0.87 | 1.50 | 2.00 | 1.00 | 1.38 | 1.75 | 1.00 | 1.00 | 1.00 | 0.60 | 0.75 | 0.83 |
| Cost | 0.54 | 0.77 | 1.38 | 0.88 | 1.13 | 1.38 | 1.17 | 1.38 | 1.88 | 1.00 | 1.00 | 1.00 |
| Technical ability | 0.63 | 1.13 | 1.63 | 0.67 | 1.00 | 1.25 | 0.79 | 0.92 | 1.25 | 0.60 | 0.92 | 1.29 |
| Customer orientation | 0.92 | 1.00 | 1.25 | 0.85 | 1.17 | 1.54 | 0.45 | 0.58 | 0.83 | 0.49 | 0.67 | 1.08 |
| Product warranties | 0.75 | 1.25 | 1.75 | 0.71 | 1.10 | 1.63 | 0.92 | 1.00 | 1.25 | 0.83 | 1.00 | 1.50 |
| Geographic location | 0.67 | 0.92 | 1.38 | 0.56 | 0.85 | 1.17 | 0.49 | 0.75 | 1.10 | 0.37 | 0.45 | 0.58 |
| Green product | 1.13 | 1.63 | 2.13 | 1.00 | 1.50 | 2.00 | 0.54 | 0.75 | 1.25 | 1.13 | 1.38 | 1.63 |

**Table-11(B)**
**The mean of the numbers of the paired comparisons' criteria's table**

| Indexes | Technical ability | Customer orientation | | | Product warranties | | | Geographic location | | | Green product | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Managing and organizing | 0.71 | 0.92 | 1.50 | 0.88 | 1.00 | 1.13 | 0.63 | 0.92 | 1.80 | 0.79 | 1.13 | 1.63 | 0.48 |
| Reliability | 0.79 | 1.13 | 1.38 | 0.98 | 1.38 | 1.67 | 0.67 | 1.04 | 1.63 | 1.30 | 1.54 | 2.00 | 0.49 |
| Product quality | 0.88 | 1.13 | 1.38 | 1.63 | 1.75 | 2.00 | 0.88 | 1.00 | 1.13 | 1.50 | 2.00 | 2.38 | 0.88 |
| Cost | 0.92 | 1.30 | 1.88 | 1.38 | 1.63 | 2.13 | 0.75 | 1.00 | 1.25 | 1.75 | 2.25 | 2.75 | 0.73 |
| Technical ability | 1.00 | 1.00 | 1.00 | 1.38 | 1.88 | 2.13 | 0.63 | 1.00 | 1.38 | 0.88 | 1.13 | 1.38 | 0.62 |
| Customer orientation | 0.59 | 0.96 | 1.10 | 1.05 | 1.06 | 1.08 | 0.54 | 0.75 | 1.25 | 0.96 | 1.38 | 2.13 | 0.48 |
| Product warranties | 0.75 | 1.00 | 1.75 | 0.88 | 1.38 | 1.88 | 1.00 | 1.00 | 1.00 | 0.92 | 1.29 | 1.88 | 0.79 |
| Geographic location | 0.79 | 0.92 | 1.25 | 0.48 | 0.79 | 1.04 | 0.58 | 0.92 | 1.29 | 1.00 | 1.00 | 1.00 | 0.60 |
| Green product | 0.75 | 1.13 | 1.63 | 1.04 | 1.50 | 1.88 | 0.88 | 1.13 | 1.38 | 1.13 | 1.50 | 1.88 | 1.00 |

For each of the matrix lines of the paired comparisons which have been supplied according to above, the value of Sk, which is the triangular fuzzy number, is calculated as below:

$$S_k = \sum_{j=1}^{n} M_{kl} \times \left[ \sum_{i=1}^{m} \sum_{j=1}^{n} M_{ij} \right]^{-1}$$

After calculating the Si s, their degree of the enlargement toward themselves can be obtained as below:

$$V(M_2 \geqslant M_1) = \mathrm{hgt}(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1, & \text{if } m_2 \geqslant m_1, \\ 0, & \text{if } l_1 \geqslant u_2, \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & \text{otherwise,} \end{cases}$$

That is, we have: $W'(x_i) = \mathrm{Min}\{V(S_i \geq S_k)\}$, k=1،2،...،n

**Table-12**
**The value of Sk**

| **(0/0086,0/0113, 0/0147)** | | | | **Si** | | |
|---|---|---|---|---|---|---|
| 7.090 | 9.380 | 13.020 | Managing and organizing | 0.061 | 0.106 | 0.192 |
| 7.140 | 9.190 | 11.950 | Reliability | 0.061 | 0.104 | 0.176 |
| 9.240 | 11.890 | 14.350 | Product quality | 0.079 | 0.134 | 0.212 |
| 9.120 | 11.340 | 14.570 | Cost | 0.078 | 0.128 | 0.215 |
| 7.200 | 9.900 | 13.060 | Technical ability | 0.062 | 0.112 | 0.193 |
| 6.326 | 8.283 | 11.360 | Customer orientation | 0.054 | 0.093 | 0.168 |
| 7.550 | 9.940 | 13.890 | Product warranties | 0.065 | 0.112 | 0.205 |
| 5.540 | 7.310 | 9.730 | Geographic location | 0.047 | 0.082 | 0.143 |
| 8.600 | 11.520 | 14.780 | Green product | 0.074 | 0.130 | 0.218 |

S1=(7.09, 9.38, 13.02)*(0/0086,0/0113, 0/0147)=(.061, .106, .192)

**Table-13**
**Calculating the degree of the enlargement of the Si s toward them**

| **Si Sj** | **Managing and organizing** | **Reliability** | **Product quality** | **Cost** | **Technical ability** | **Customer orientation** | **Product warranties** | **Product warranties** | **Green product** |
|---|---|---|---|---|---|---|---|---|---|
| Managing and organizing | | 1.000 | 0.800 | 0.838 | 0.957 | 1.000 | 0.953 | 1.000 | 0.831 |
| Reliability | 0.982 | | 0.761 | 0.802 | 0.935 | 1.000 | 0.930 | 1.000 | 0.796 |
| Product quality | 1.000 | 1.000 | | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Cost | 1.000 | 1.000 | 0.956 | | 1.000 | 1.000 | 1.000 | 1.000 | 0.986 |
| Technical ability | 1.000 | 1.000 | 0.835 | 0.876 | | 1.000 | 0.996 | 1.000 | 0.867 |
| Customer orientation | 0.896 | 0.912 | 0.685 | 0.722 | 0.853 | | 0.846 | 1.000 | 0.720 |
| Product warranties | 1.000 | 1.000 | 0.851 | 0.889 | 1.000 | 1.000 | | 1.000 | 0.880 |
| Geographic location | 0.780 | 0.795 | 0.555 | 0.590 | 0.737 | 0.891 | 0.727 | | 0.595 |
| Green product | 1.000 | 1.000 | 0.971 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | |

Calculating the weight of the criteria in the paired comparisons' matrix is according to the second step:

**Table-14**
**Weight of the criteria in the paired comparisons' matrix**

| criteria' abnormal weight | | criteria' normalized weight |
|---|---|---|
| S1>Si | 0.800 | 0.108 |
| S2>Si | 0.761 | 0.103 |
| S3>Si | 1.000 | 0.135 |
| S4>Si | 0.956 | 0.129 |
| S5>Si | 0.835 | 0.113 |
| S6>Si | 0.685 | 0.092 |
| S7>Si | 0.851 | 0.115 |
| S8>Si | 0.555 | 0.075 |
| S9>Si | 0.971 | 0.131 |

Min V (S1≥ S2,S3,S4, S5, S6,S7,S8, S9) = Min (1, ./80, ./838, ./957, 1 , ./953, 1, ./831) =./80

So, the criteria' abnormal weight vector will be as below:
W' = (0/80 ,0/761 , 1,0/956 , ./835 , 0/685, 0/851, ./555 , 0/971)

Fourth step) finally, we normalize the weight vector obtained from the third step by the below relation and the vector of the criteria's weight will be according to the below table:

$$w_i = \frac{w_i'}{\sum w'}$$

By attending to the above calculations, the quality criterion with 0.135 weights has the most important. So, it is in the high priority. The green production criterion with 0.131 weights is in the second priority. The geographic location criterion with minimum weight (0.075) has been in the last priority. Table 9-4 shows the criteria's fuzzy weight.

## Conclusion

By attending to the above calculations, the quality criterion with 0.135 weights has the most important; so, it is in the high priority. The green production criterion with 0.131 weights is in the second priority. The cost criterion with 0.129 weights is in the third priority. The production warranty with 0.115 weights is in the fourth priority. The technical ability criterion with 0.113 weights is in the fifth priority. The management and organizing criteria with 0.108 weights are in the sixth priority. The management and organizing criteria with 0.103 weights are in the seventh priority. The customer criterion with 0.092 weights is in the eighth priority. The geographic location criterion with minimum weight (0.075) has been in the last priority.

Using the FAHP method, the suppliers' final ranking also is as follow: The first rank is for the fourth supplier with 0.332 weights. The second rank is for the second supplier with 0.199 weights. The third rank is for the first supplier with 0.194 weights. The fourth rank is for the fifth supplier with 0.142 weights. The fifth rank is for the sixth supplier with 0.133 weights.

## References

1. Ghodsypour S.H. and Obrien C., The total cost of logestics in supplier selection , under conditions of multiple sourcing ,multiple criteria and capacity constraints, *International journal of production economics*, 15-27 **(2001)**
2. Jaefarnejad A., Ajdari B. and Saleh M.R., Using data envelopment analysis and cross-efficient method for evaluating suppliers, engineering companies thought Farafan, Second National Conference on Performance Management **(2007)**
3. Azadeh A., Ghaderi S.F., Javaheri Z. and Saberi M., A fuzzy mathematical programming approach to DEA models, *Am. J. Applied Sci.,* **5,** 1352-1357 **(2008)**
4. Sawik T., Single vs. multiple objective supplier selection in a make to order environment, *Omega*, **38**, 203-212 **(2010)**
5. Kheljani J.G., Ghodsypour S.H. and O'Brien C., Optimizing whole supply chain benefit versus buyer's benefit through supplier selection, *Int. J. Product. Econ.,* **121**, 482-493 **(2009)**
6. Lee A.H.I.,, A fuzzy supplier selection model with the consideration of benefits, opportunities, costs and risks, *Expert Syst. Appli.,* **36**, 2879-2893 **(2009)**
7. Yang J.L., Chiu H.N., Tzeng G.H. and Yeh R.H., Vendor selection by integrated fuzzy MCDM techniques with independent and interdependent relationships, *Inform. Sci.,* **178**, 4166-4183 **(2008)**
8. Choi T.Y. and Hatly J.L., An exploration of supplier selection practices across the supply chain, *J. Oper. Manage.,* **14(4),** 333-343 **(1996)**
9. Oxenfeldt A., Cost Bene"t Analysis for Executive Decision Making: the Danger of Plain Common Sense, Amacon, New York (**1979**)
10. Pinsoneault A. and Kraemer K.L., The e!ects on electronic meetings on group processes and outcomes: an assessment of the empirical research, *European Journal of Operational Research*, **46**, 143-161 **(1989)**
11. Ellram L.M., The supplier selection decision in strategic partnerships, *J. Purchas. Material Manage*, **26**(**4**), 8-12 **(1990)**
12. Chaudhry S.S., Forst F.G. and Zydiak J.L., Vendor selection with price breaks, *European Journal of Operational Research,* **70**, 52}66 **(1993)**
13. Rosenthal E.C., Zydiak J.L. and Chaudhry S.S., Vendor selection with bundling, *Decision Sciences*, **26**(**1**), 35}48 **(1995)**

**14.** Sadrian A.A. and Yoon Y.S., A procurement decision support system in business volume discount environments, *Operations Research*, **42(1)**, 14-23 **(1994)**

**15.** Ganeshan R., Tyworth J.E. and Guo Y., Dual sourced supply chains: the discount supplier option, *Transportation Research Part E*, **35**, 11-23 (**1999)**

**16.** Weber C.A., Current J.R. and Benton W.C., Vendor selection criteria and methods, *Eur. J. Oper. Res.,* **50(1)**, 2-18 **(1991)**

**17.** Ghodsypour S.H. and O'Brin C., A decision support system for supplier selection using an integrated analytic hierarchy process and linear programming, *Int. J. Product. Econ.,* **56-57(1-3)**, 199-212 **(1998)**

**18.** Dickson G.W., An analysis of vendor selection system and decisions, *J. Purchas.,* **2(1)**, 28-41 **(1966)**

**19.** Wang H.S., Configuration change assessment: Genetic optimization approach with fuzzy multiple criteria for part supplier selection decision, *Expert Syst. Appl.,* **34(2),** 1541-1555 **(2008)**

**20.** Kahraman C., Cebeci U. and Ulukan Z., Multi-criteria supplier selection using fuzzy AHP. Logistics Inform, *Manage*, **16**, 382-394 **(2003)**