Middle-East Journal of Scientific Research 8 (2): 328-336, 2011
ISSN 1990-9233

Selecting Suppliers for Iran Tractor Manufacturing Company Using Technique for Order-Preference by Similarity to Ideal Solution

[1]*Soleyman Iranzadeh* and [2]*Farzam Chakherlouy*

[1]Department of Management, Tabriz Branch, Islamic Azad University, Tabriz, Iran
[2]Tabriz Branch, Islamic Azad University, Tabriz, Iran

Abstract: The objective of this research is to study the market and choosing the most appropriate supplier based on the important performance criteria by using multiple attribute decision making models (MADM methods). Researching in the purchase market and selecting the most appropriate provider is one of the most important activities in today organizations. Lack of attention to parts and materials supply conditions in each system and cooperation with providers may lead to the increase of purchasing costs, quality control and quality guarantee costs and ultimately customer dissatisfaction to the final products and services. Ranking and selecting of suppliers in order to cooperate in providing the parts must be accomplished respecting to several criteria and indicators. In the present research, first of all important criteria in evaluating and ranking the suppliers of the Iran Tractor Manufacturing Company have been specified based on library studies and interviews with experts and then the degree of importance of each criteria was determined using a questionnaire and based on Shannon entropy method. Regarding the problem conditions, evaluating of the Multiple Attribute Decision Making models indicated that TOPSIS model3 was the most appropriate Multiple Attribute Decision Making model in order to ranking the suppliers of the company. According to data obtained and using the TOPSIS model, supplier's performances were studied and each one's rank was determined.

Key words: Multiple attribute decision making (MADM) · Supply chain management (SCM) · TOPSIS model · MODM · MCDM

INTRODUCTION

Today, considering the increasing role of supplier in the companies' business chain, relations management with suppliers are becoming very important issues to business corporate and producers. Organizations in order to obtain better results in competitive markets need to take a correct decision on relations with suppliers [1]. Researching in the purchase market and choosing the most appropriate supplier is one of these decisions. Lack of attention to supply parts and materials in any system and cooperation with suitable suppliers may lead to increase the cost of purchasing, quality control and quality guarantee costs and ultimately customer dissatisfaction to final products and services [1]. Therefore, organizations and companies dealing with a large network of suppliers at different levels, they need to evaluate and assess their suppliers based on various criteria and determine the rank of each supplier [2].

Today, most of the issues presented to managers for decision making and even our everyday problems has various aspects and requires the attention to simultaneous effect of several variables and the relationship between them [3]. In other words, final decision can not be taken considering only one variable and its optimization. Naturally solving such issues is complex and is not easily possible, especially that most of the variables have conflict with each other and an increase in one variable's desirability can reduce desirability of another [4]. Therefore some methods which are called Multiple Criteria Decision Making were developed in which divided into two major parts: Multiple Objective Decision Making and Multiple Attribute Decision Making. These methods help us to choose the best option considering several criteria. In prioritization issue and selection of suppliers, considering several criteria, interaction between the criteria and their simultaneous impact makes it difficult to decide.

Corresponding Author: Soleyman Iranzadeh, Department of Management, Tabriz Branch, Islamic Azad University, Tabriz, Iran. Tel/Fax: +98 914 734 0262.

Criteria such as quality of goods received, price and cost conditions, delivery Status and many other criteria are considered in effective selection of suppliers. Therefore some methods called Multiple Attribute Decision Making have been developed. These methods help us choose the best option according to several criteria [5]. A number of studies performed on the supplier selection with the multi criteria decision making approach are presented. Decision making is the process of choosing the best action or alternative among the current choices. Multi criteria decision making is one of the most useful branches of decision making science. So far, many methods about multi criteria decision making such as analytical hierarchical process (AHP), multi criteria utility theory, linear weighting models and other techniques have been developed which all have been applied for the supplier selection problem as well. A large number of researchers used AHP method for many multi criteria decision making problems. Ghodsypour and O'brien [6] presented a decision support system for evaluation of suppliers based on AHP approach. Saaty and Cho [7] used the AHP for examining China trade status for the U.S. congress. Liu and Hai [8] applied the AHP approach for supplier selection problem. Weber *et al*. [9] applied an optimal solution using multi objective programming and data envelopment analysis (DEA) methods. They considered a problem with a number of suppliers and one product. They firstly, using multi objective programming selected the best supplier. Then, they evaluated the efficiency of the chosen supplier through the DEA technique. Identification and analysis of supplier selection criteria for evaluation and choosing the suppliers have been studied in many papers. One of the most basic and valid papers on examination of different supplier selection criteria is the paper written by Dickson [10]. This paper which has so far been referred in many papers is based on 273 questionnaires which were distributed between managers selected from the roster of national society of purchasing managers. This roster included managers from US and Canada. Dickson [10] determined 23 basic and important criteria. The primitive research of Dickson [10] which was many years a basis for work of different researchers in identifying influencing factors in assessment and selection of the supplier was reviewed by Weber *et al*., (1991). Another comprehensive research on identification of effective factors in supplier selection is Cheraghi *et al*. [11]. The objective of present research is ranking the Iran Tractor Manufacturing Company's suppliers based on important criteria of performance and using TOPSIS model. In order to achieve this goal, the following secondary objectives will be followed:

- Determining the most important performance criteria of the Iran Tractor Manufacturing Company's suppliers;
- Determining the degree of importance for each criterion.

Research Methodology: The method of present Study is practical in terms of objective and surveying research in terms of method. The statistical society of this research includes all the experts in the parts supply section of the Iran Tractor Manufacturing Company and statistical sampling is not performed and all members of society will be evaluated.

Data Collection Method: Data required for this study has been collected using questionnaire, interview, library studies and available documents in Iran Tractor Manufacturing Company. In order to rank the suppliers using multiple attribute decision making method, we need the following data:

- Options (parts supplier);
- Criteria;
- Degree of importance of each criterion;
- Decision matrix (this matrix contains scores of suppliers in each criterion; each matrix element indicates the score of each supplier in one criteria).

In order to know the options and important criteria in ranking the options, the latter company documents, interviews with experts of parts supply section and library study are used. To determine the importance of each criteria and preparing the decision matrix, a questionnaire use has been used. For this purpose two types of Questionnaire distributed between experts of parts supply section of Iran Tractor Manufacturing Company in which at the first questionnaire requested people to grade the importance of each of the criteria listed in the questionnaire in range of 1-10. In the second questionnaire which contains scores from two groups of suppliers, people were asked to score each supplier in each criterion in the range of 1-10.

Evaluating different multiple attributes decision making models (discussed before) indicates that these models are divided into two major categories of compensating models and non-compensating models.

Non-compensating models include methods in which the desirability exchange between attributes is not allowed and it means that desirability decrease of the decider due to existing weakness in one attribute can not be compensated by existing advantages of another attribute. Therefore in this method each attribute is not considered alone and comparison is accomplished from one attribute to another one [12].

Compensating models include methods that allow desirability exchange between attributes and it means that desirability decrease in one attribute due to a change (probably small) could be compensated by an opposite change in another attribute (or attributes) [12].

Since in the supply chain, each supplier might have pivotal capabilities or special advantages in one or more performance compared to other competitors and has no advantage in some of the activities compared to competitors, in ranking and selecting of suppliers using this method, it is possible to improve the performance statues of one supplier through its comparative advantage in some areas, despite its poor performance in other areas, so there is possibility to exchange attributes in existing problems and the models used for assessment and ranking of the suppliers will be a compensating model in which these models are divided into three main subgroups:

- Grading and Rating subgroup.
- Harmonic subgroup.
- Customized subgroup.

Grading and Rating Subgroup: the Methods of this Group Are: Simple aggregate weighty method (SAW), ranked aggregate weighty method and Simple aggregate weighty method with interaction. Models belongs to this subgroup do not allow attributes interaction (same reference). It means if the attributes have supplement or replacement effects on each other (for example, an increase in one attribute causes a decrease in another one) it is better not to use this group models.

Since in ranking and selecting the suppliers problem, all attributes affect each other (eg quality affects the price and costs and costs affect the quality reversely), therefore using this subgroup models will lead to unrealistic results in suppliers ranking.

Harmonic models (eg ELECTRE model), these models are very sensitive to the type of weighting technique and attributes weighting method has a profound impact on the results of these models.

On the other hand, determinant risk has a drastic impact on the results of these models and applying these models are appropriate for such conditions that allows more risk for determinant.

Regarding the sensitivity of the topic, choosing the most appropriate suppliers in which has less risk and need more precise decisions and also in order to more control the possible effects of the weighting method on the results, using constructive subgroup models are preferred to harmonic subgroup models.

In constructive subgroup, the preferred option would be the closest option to the ideal solution. Models belong to this subgroup include:

- TOPSIS
- LINMAP

LINMAP method is appropriate for specific cases in which the most appropriate value of an attribute is located in the middle of domain changes of that attribute. It means that number 4 is preferred to number 3 and 5.

Since in the ranking of suppliers, if always one supplier has better condition in one attribute, it will have a higher score in the range of 1-10 and therefore using LINMAP method is not suitable.

For ranking and selecting the most appropriate suppliers TOPSIS method is more appropriate due to the following reasons:

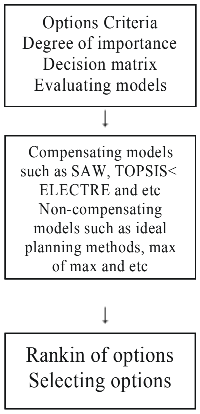
In this technique, due to permission of desirability exchange between the attributes, it is possible to improve a supplier performance through its comparative advantage in some areas, despite its poor performance in other areas.

In TOPSIS decision making technique, interaction effect of attributes is considered. This technique also considers Conflict and compatibility between attributes [12, 13, 14].

TOPSIS decision making technique is less sensitive compared to weighting technique.

Considering the subjects covered in this study, compensating models and its constructive subgroup, TOPSIS technique, is used for evaluating and ranking the suppliers.

Data Analysis: If we look at data analysis in a systematic approach, the following configuration will be appeared in which the specified input from questionnaire and field studies including determining options and evaluation criteria and also determining the degree of important of each criteria which obtained by questionnaires and also determining the decision matrix and finally reviewing the model and finding its solution can achieve the optimized and effective answers using compensating or non-compensating models and ultimately results obtained from different available compensating and non-compensating models and techniques could be applied for ranking and identifying the most appropriate suppliers.



In order to analysis and rank the suppliers, following items are adopted:

- First stage: identifying options;
- Second stage: determining evaluation criteria;
- Third stage: weight and degree of importance of each criteria;
- Fourth stage: determining the decision matrix with the help of experts;
- Fifth stage: reviewing MADM models and selecting the appropriate model,
- Sixth step: Running the model and determining the best option or options respectively.

First Stage: Identifying Options: In order to select the best option or rank all available options each problem is defined. To select the best suppliers, options are the same parts supply companies which are as follows:

Second Stage: Determining Evaluation Criteria for Iran Tractor Manufacturing Company Suppliers: According to theoretical study and field studies on suppliers' quality and respected professors' comments during meetings with experts of Iran Tractor Manufacturing company's parts supply department, the most important criteria for evaluating suppliers of the company has been extracted in Table (2):

Third Stage: Weighting to Each Criteria Used in Evaluating and Ranking the Suppliers: Considering the fact that in multiple attribute decision making problems we need to know the relative importance of the available attributes, so that their sum must be equal to one (normalized), therefore it is necessary to determine the degree of importance of each evaluation criteria. For this reason, before weighting, first of all a questionnaire is prepared and company experts been asked to grade the importance of each criterion in evaluation and ranking of the suppliers from 1 to 10. After collecting the questionnaires, the weighting matrix (Table 3) is determined based on the information obtained.

Table 1: suppliers of the finished forged parts

Row	1	2	3	4	5	6
Company Name	X_1	X_2	X_3	X_4	X_5	X_6

Table 2: Evaluating and ranking criteria for Iran Tractor Manufacturing Company suppliers

Row	Criteria	Definitions
1	Quality	A Degree in which product is matched with customer expectations and specifications presented [15, 16]. (ability to provide application Features, structural specifications, technical and environmental)
2	Set Price (Pricing)	Set price for the product offered considering the costs and market price, product quality and etc [17]
3	Price flexibility (discount conditions)	Apply special conditions for discount in prices
4	Reliability in delivery required amounts	Deliver the required amounts steadily to the company [18]
5	Reliability in timely delivery	Delivery at the time required and steadily
6	Flexibility in delivery	Management of special conditions for deliveries with special and critical conditions in terms of time, amount or number of deliveries
7	Promotion activities and incentives	A series of activities, including advertising, personal sales, promotional sales, public relations
8	Securing Policies	Quality assurance policies, including the warranty terms and etc
9	Participation in Quality Improvement	Partnership with customers to improve product design, raw materials used in the product and improve the structural and functional specifications
10	Cooperation in transport	space terms of delivery and the amount of supplier cooperation in transport purchased products
11	Packaging conditions	Appropriate packaging for products
12	Easy ordering	Providing conditions for easy sending and receiving all the order documents and perform ordering procedures
13	Easily returned	Easy Returns of Product, responding to the complaints
14	Communication and Information	Providing useful and necessary information to the buyer, equipped with communications systems between the organization
15	Sales Support	Provide After-sales services to the buyer company

Table 3: Weighting matrix

Row	Quality	Set Price (Pricing)	Price flexibility	Reliability in delivery required amounts	Reliability in timely delivery	Flexibility in delivery	Promotion activities and incentives	Securing Policies	Participation in Quality Improvement	Cooperation in transport	Packaging conditions	Easyq ordering	Easily returned	Communication and Information	Sales Support
1	7	8	7	7	6	7	8	6	7.5	7.5	6	7	8.75	6.75	7.5
2	8	7.5	6.5	8	7	6.5	7	7	6.5	6.5	7	6	7.5	6.5	6
3	7	7.5	7	7.5	6	6.5	6.5	7.25	7.75	7.5	6.5	7	6.5	7.25	6
4	6	7	6	6	8	6	5.5	9	7.25	6	6.5	7.75	6	8	7
5	6.5	6	8	7	7.75	7	6	6	7.5	7	7	9	7	7.5	6.5
6	6.5	6	7	7.5	6.25	7.75	7	7	6.5	7.75	7.5	6.75	7.5	6.5	6
7	7.5	6	6	8.5	6	7.25	7.75	6.5	6	7.25	8	7.25	7	7.5	7
8	7	8	5.75	7.5	5.75	6.25	7	6	7	5.75	8.75	7	7.5	6	5.5
9	7.75	7	6	7	7.5	6.5	6	8	6.5	6.25	7.5	6	6	7.5	8
10	6.5	6	7	6	6.5	6.75	6.5	7	6	7	8	6	5.5	6.5	7
11	7	6	8	6.5	7	6	7	6	8	7	7.5	8	7	7	7.5
12	7	6	7	6	6	7	7	5.75	7.5	8	6	8.5	6	7.35	5.5
13	6	6.5	6.25	7	6.5	6.5	8.25	7	7	7.5	6	6.5	7.5	6.5	6.5
14	5.75	8	6	8.25	7.5	6	9	7	8	6.5	6.5	7	6.5	7	7.5
15	8	7	7.25	6.5	6.75	8	6.5	8	9	6.5	5.5	6.25	7	6	7.5
16	8.5	6.25	7	7	8.25	8.5	6	7	6	7	7.5	5.75	6	8	8
17	6.5	6.25	8	6	9	7	7	7.5	6.5	6.5	7.5	6	5.5	7.5	7.5
18	7.5	6.5	9	7	6	7	6.5	6.5	7.5	6	7	6	7	7.5	8.5
19	6.75	7.5	6	6	6.5	7.5	6	7	7	8	6	7	9	6	7.75
20	7.25	8	6	6	7	8.5	8	7	6	8.5	6.5	7	7	7	8.25
21	8	8.5	7	8	6.5	7	8.5	8	7	7	6	6.5	6.5	5.75	7
22	8.25	6.5	6.75	8.5	6	5.75	7.25	8	5.5	7	6.5	8.5	8	6.25	6.5
23	8.5	6	6	8	8	6	6.75	7.5	6	7.5	8.25	6	7	9	7.5
24	6.5	7	8	7.75	8.5	6	7.5	6	7	8.25	7	7	8.25	8.5	6.5
25	7	6	8.5	6	7.25	7	7	6.75	6	7.75	6	7	7.5	6.75	7
26	6.25	6	7.5	6	6.75	8	6	6	6	8.5	6.5	7.5	6.5	7.25	7
27	6.5	8	6.5	6	7.5	7	6.5	6.25	7.5	6	7	6.5	7.5	6	8
28	6	8.25	7.5	6.5	7	6	6	8	7	6.5	7.5	7.5	7	6	7
29	8	7	7	7	7.75	6.25	7	8.5	7	5.5	8	7.5	6	7	7.5
30	7	6.5	8	7	7.5	7.5	6	7	8	5.75	8.5	7	6.5	6.5	5.5
31	5.5	7	7	6.5	6.5	6.5	7.5	7	8.5	6.25	6.5	6.5	7.5	6	7
32	6	7.5	7	8	6	8	7	6	6	6	6	8.25	6.5	6	6
33	6	8.25	6	6	7	9	8	6	7	7.5	7	6	7	8.5	6

Then we calculate the available information content in the matrix as a normalized form.

And for Ej from Pij collections, for each attribute we will have:

$$P_{ij} = \frac{R_{ij}}{\sum_{i=1}^{m} R_{ij}}$$

So that is.

$$K = \frac{1}{L_{nm}}$$

$$E_j = -k\sum_{i=1}^{m}(P_{ij}.LnP_{ij})$$

Now the uncertainty or degree of deviation (dj) from the created information for the j th attribute is as follow:

And finally for weights (Wj) of the available attribute will have:

$$W_j = \frac{d_{ij}}{\sum_{i=1}^{n} d_{ij}}$$

Therefore in this method to calculate the weight of each criterion we need to prepare: 1- dimensionless matrix (Pij) 2- calculating the Ej attribute 3- calculating the dj attribute.

Weighting to each of the evaluation criteria and ranking the suppliers is as below:

Pij de-scaled matrix is determined by division of each column elements to the sum of elements of that column. These values must be calculated one by one and replaced in a matrix similar to the previous matrix, for example the value for first row and first column is equal to 0.030501 and for the first column and second row is equal to 0.034858 and so on.

After determining the de-scaled matrix, Ej attribute and degree of deviation from created information (dj) could be calculated. Table (4) indicates these values:

Finally, using the following formula:

$$W_j = \frac{d_{ij}}{\sum_{i=1}^{n} d_{ij}}$$

Table 4: Degree of deviation from established information

Criteria	Ej	(dj)= 1-Ej
Quality	0.998062	0.001938
Set Price (Pricing)	0.997975	0.002005
Price flexibility (discount conditions)	0.998019	0.001981
reliability in delivery required amounts	0.998021	0.001979
Reliability in timely delivery	0.998022	0.001978
Flexibility in delivery	0.998030	0.001970
Promotion activities and incentives	0.998168	0.001832
Securing Policies	0.998079	0.001921
Participation in Quality Improvement	0.998075	0.001925
Cooperation in transport	0.998068	0.001932
Packaging conditions	0.998131	0.001869
Easy ordering	0.998028	0.001972
Easily returned	0.998042	0.001958
Communication and Information	0.998073	0.001927
Sales Support	0.998103	0.001897

Table 5: specified weights for each criterion

Criteria	Weight (Wij)
Quality	0.0666
Set Price (Pricing)	0.0670
Price flexibility (discount conditions)	0.0662
reliability in delivery required amounts	0.0661
Reliability in timely delivery	0.0661
Flexibility in delivery	0.0658
Promotion activities and incentives	0.0612
Securing Policies	0.0641
Participation in Quality Improvement	0.0643
Cooperation in transport	0.0645
Packaging conditions	0.0624
Easy ordering	0.0659
Easily returned	0.0654
Communication and Information	0.0644
Sales Support	0.0634

Weight of e ach criterion can be determined. Table (5) shows the weight of criteria:

Fourth Stage: Determining the Decision Matrix with the Help of Experts: The purpose of decision matrix is to prepare a matrix consisting of options and criteria for ranking the Options. For this purpose, a questionnaire consisting of the names of parts suppliers companies for each group of parts and criteria for evaluating their performance prepared and distributed between all the experts. In the questionnaire experts were asked to score each of the parts supply companies for the criteria specified. After collecting the questionnaire, the score of each supplier for each criterion will be the geometric mean of scores that experts assigned to the company for that criterion. Therefore, the final score written in each cell of the decision matrix is coming from the average scores assigned by experts to that cell. Table (6) shows the final decision matrix for two groups of parts suppliers.

Fifth Stage: Reviewing Multiple Attributes Decision Making Models and Selecting a Suitable Model for Ranking the Suppliers: According to the performed reviews which also mentioned in the research methodology, TOPSIS technique has been used for ranking and selecting the most appropriate suppliers.

Sixth Stage: Running the Model and Determining the Best Option:

- Ranking the suppliers of forged parts using the TOPSIS model.

Table 6: Decision matrix for suppliers of finished forged parts

	Criteria														
Company	Quality	Pricing	Flexibility	Reliability in delivery	On time delivery	Flexibility in delivery	Promotion activities and incentives	Securing Policies	Participation in Quality Improvement	Cooperation in transport	Packaging conditions	Easy ordering	Easily returned	Communication and Information	Sales Support
X1	6/02	7	6/27	7/23	8/01	8/24	6	8/31	7/24	7/09	8/14	7/42	7/35	9	8/34
X2	5/24	6/5	5/12	7/19	6/3	6/17	5/12	6/22	5/37	7	6/08	6/23	6/09	7/52	6/57
X3	5	5/23	4/13	6/06	6	6	4/13	6/04	5	6/04	6/24	5/49	5/52	7/48	6
X4	6	7/03	5/82	7	7/15	8/05	6	7/52	7	7	7/13	6	7/35	8/37	8/03
X5	4/72	5/67	4/23	4/45	6/23	6/16	4/16	6	6/38	6/03	5/16	6	6/06	7	7
X6	7/1	8	5/41	7	7/52	6	7/42	7/62	6	7/17	8	8/05	8/01	9	8/04

Table 7: Normalized matrix for suppliers

	Criteria														
Company	Quality	Pricing	Flexibility	Reliability in delivery	On time delivery	Flexibility in delivery	Promotion activities and incentives	Securing Policies	Participation in Quality Improvement	Cooperation in transport	Packaging conditions	Easy ordering	Easily returned	Communication and Information	Sales Support
X1	0/4284	0/4306	0/4901	0/4318	0/4733	0/4918	0/4380	0/4839	0/4753	0/4294	0/4833	0/4594	0/4420	0/3536	0/4613
X2	0/3729	0/3991	0/4002	0/4294	0/3723	0/3682	0/3737	0/3622	0/3525	0/4240	0/3610	0/3857	0/3662	0/3790	0/3634
X3	0/3558	0/3217	0/3228	0/3619	0/3545	0/3581	0/3015	0/3517	0/3282	0/3658	0/3705	0/3399	0/3319	0/3770	0/3318
X4	0/4270	0/4325	0/4549	0/4181	0/4225	0/4804	0/4380	0/4379	0/4596	0/4240	0/4233	0/3715	0/4420	0/4219	0/4441
X5	0/3359	0/3488	0/3306	0/3852	0/3681	0/3676	0/3036	0/3494	0/4189	0/3652	0/3063	0/3715	0/3644	0/3528	0/3871
X6	0/5053	0/4922	0/4229	0/4181	0/4444	0/3581	0/5416	0/4437	0/3939	0/4343	0/4750	0/4984	0/4817	0/4536	0/4447

Table 8: Indicates the V matrix

	Criteria														
Company	Quality	Pricing	Flexibility	Reliability in delivery	On time delivery	Flexibility in delivery	Promotion activities and incentives	Securing Policies	Participation in Quality Improvement	Cooperation in transport	Packaging conditions	Easy ordering	Easily returned	Communication and Information	Sales Support
X1	0/4284	0/4306	0/4901	0/4318	0/4733	0/4918	0/4380	0/4839	0/4753	0/4294	0/4833	0/4594	0/4420	0/3536	0/4613
X2	0/3729	0/3991	0/4002	0/4294	0/3723	0/3682	0/3737	0/3622	0/3525	0/4240	0/3610	0/3857	0/3662	0/3790	0/3634
X3	0/3558	0/3217	0/3228	0/3619	0/3545	0/3581	0/3015	0/3517	0/3282	0/3658	0/3705	0/3399	0/3319	0/3770	0/3318
X4	0/4270	0/4325	0/4549	0/4181	0/4225	0/4804	0/4380	0/4379	0/4596	0/4240	0/4233	0/3715	0/4420	0/4219	0/4441
X5	0/3359	0/3488	0/3306	0/3852	0/3681	0/3676	0/3036	0/3494	0/4189	0/3652	0/3063	0/3715	0/3644	0/3528	0/3871
X6	0/5053	0/4922	0/4229	0/4181	0/4444	0/3581	0/5416	0/4437	0/3939	0/4343	0/4750	0/4984	0/4817	0/4536	0/4447

First step: converting the decision matrix to de-scaled matrix using the following formula:

$$nij = \frac{rij}{\sqrt{\sum_{i=1}^{m} r_{ij}^2}}$$

Table 7 shows the de-scaled matrix:

Second step: Calculating the weighty de-scaled matrix (v): This matrix is determined from the matrix W multiply by the de-scaled matrix (ND) in which ND is a matrix that the attributes scores are de-scaled and comparable and W n × n is a diagonal matrix in which only its major diameter elements will be non-zero (Table 8).

Third step: specifying the ideal solution and negative ideal solution:

We define (A +) for ideal option and (A-)for negative ideal as below:

$$A^+ = \{(\max_i V_{ij} \mid j \in J), (\max_i V_{ij} \mid j \in J') \mid i = 1,2,...,m\} = \{V_1^+, V_2^+, ... V_j^+, V_n^+\}$$

$$A^- = \{(\max_i V_{ij} \mid j \in J), (\max_i V_{ij} \mid j \in J') \mid i = 1,2,...,m\} = \{V_1^-, V_2^-, ... V_j^-, V_n^-\}$$

j=J=1,2,…, n for J's related to profits

J'=J=1,2,…, n for J's related to costs

Ideal solution A -		Ideal solution A +	
0223/0	Vi1	0336/0	Vi1
0215/0	Vi2	0329/0	Vi2
0213/0	Vi3	0324/0	Vi3
0239/0	Vi4	0285/0	Vi4
0234/0	Vi5	0312/0	Vi5
0235/0	Vi6	0323/0	Vi6
0184/0	Vi7	0331/0	Vi7
0223/0	Vi8	0310/0	Vi8
0211/0	Vi9	0305/0	Vi9
0235/0	Vi10	0280/0	Vi10
0191/0	Vi11	0301/0	Vi11
0224/0	Vi12	0328/0	Vi12
0217/0	Vi13	0315/0	Vi13
0227/0	Vi14	0292/0	Vi14

Step Four: Calculating the distances:

Distance between I th options to the ideals using Euclidean method is as below:

$$\left\{\sum_{j=1}^{n}\left(V_{ij}-V_{j}^{+}\right)^{2}\right\}^{0.5} \quad ;i=1,2,...,m$$

$$\left\{\sum_{j=1}^{n}\left(V_{ij}-V_{j}^{-}\right)^{2}\right\}^{0.5} \quad ;i=1,2,...,m$$

Table (9) shows the distance of all suppliers from ideal and negative ideal:

Fifth step: Calculating the relative closeness of each option to the ideal:

We define this closeness as follow:

$$cl_{i+}=\frac{d_{i-}}{\left(d_{i+}+d_{i-}\right)};0\le cl_{i+}\le 1;i=1,2,...,m$$

If A=A+ then di=0 and we will have cli+=1 and if A=A-, then di=0 and we will have cli+=0. Therefore the closer the Ai to the ideal solution (A+), the CLi+ value closer to one.

Table 10 shows the relative closeness of the options (suppliers) to the ideal.

Step Sixth: Ranking the Options: Finally, based on the calculations we can rank the suppliers of finished forged parts as described in Table (11).

As observed in ranking the supplier of finished forged parts using the TOPSIS model we applied six steps and eventually suppliers options were ranked.

Table 9: Distance from the positive and negative ideal solution

Suppliers	(di+) Distance from ideal	(di-) Distance from negative ideal
X1	0/009844	0/031149
X2	0/026897	0/012293
X3	0/35435	0/004497
X4	0/014414	0/025193
X5	0/033016	0/007889
X6	0/011709	0/032403

Table 10: relative closeness of the options

Suppliers	Cli +
0/7598	X1
0/3136	X2
0/1126	X3
0/6360	X4
0/1928	X5
0/7345	X6

Table 11: Options rank based on relative closeness to ideal

Rating	Cli +	Suppliers
1	0/7598	X1
2	0/7345	X6
3	0/6360	X4
4	0/3136	X2
5	0/1928	X5
6	0/1126	X3

CONCLUSION AND SUGGESTION

There is a difference between this study and other investigations in that the Iran Tractor Manufacturing Company has relationships with a wide network of suppliers at different levels, thus this study investigates the conditions of suppliers, their ranking and selection the best and most appropriate of them for collaboration with the Iran Tractor Manufacturing Company in order to achieve the strategic objectives of the Company using the TOPSIS technique. In this study, the criteria considered in ranking the suppliers of Iran Tractor Manufacturing Company, were extracted based on Theoretical study, interviews with experts of supply department and documents studies and the degree of importance for each of them was determined. Based on the results, criteria such as pricing with a weight equal to 0.067, quality with a weight of 0.0666, flexibility in price with a weight of 0.0662, had the most importance in ranking the suppliers and criteria such as: packaging conditions with a weight of 0.0624 and promotion activities and incentives with a weight of 0.0612 had the least importance than other criteria in ranking the Iran Tractor Manufacturing Company suppliers and ultimately according to the results obtained from data analysis and ranking the suppliers of finished forged parts based on the TOPSIS model, the relative closeness to ideal index for each of the options (suppliers) determined and suppliers were ranked respecting the obtained points.

Suggestions for Future Research: Considering the importance of using fuzzy logic in multiple attributes decision making models, ranking and selecting the most appropriate suppliers for companies must be according to MADM fuzzy model in which it might give more precise results. Therefore, applying the multiple attribute decision making models and Fuzzy models will be a good topic for future researches.

REFERENCES

1. Wynstra, F. and E.T. Pierick, 2000. Managing supplier involvement in new product development: a portfolio approach, Eur. J. Purch and Sup Man, 6: 49-57.
2. Keskin, G.A., S. İlhan and C. Özkan, 2010. The Fuzzy ART algorithm: A categorization method for supplier evaluation and selection, Ex Sys With App., 37: 1235-1240.
3. Xia, W. and Z. Wu, 2007. Supplier selection with multiple criteria in volume discount environments, Omega, 35: 494-504.
4. Amid, A., S.H. Ghodsypour and C. O'Brien, 2006. Fuzzy multiobjective linear model for supplier selection in a supply chain, Int. J. Pro. Eco., 104: 394-407.
5. Lee, A.H.I., H.J. Chang and C.Y. Lin, 2009. An evaluation model of buyer-supplier relationships in high-tech industry - The case of an electronic components manufacturer in Taiwan, Com and Ind Eng., 57: 1417-1430.
6. Ghodsypour, S.H and C. O'Brien, 1998. A decision support system for supplier selection using an integrated analytic hierarchy process and linear programming. International Journal of Production Economics, 56: 199-212.
7. Saaty, T.L. and Y. Cho, 2001. The decision by the US congress on China's trade status: a multicriteria analysis. Socio-Economic Planning Sci., 35(4): 243-252.
8. Liu, F.H. and H.L. Hai, 2005. The voting analytic hierarchy process method for selecting supplier. International J. Production Economics, 97(3): 308-317.
9. Weber, C., J.R. Current and W.C. Benton, 1991. Vendor selection criteria and methods. European J. Operational Res., 50(1): 2-18.
10. Dickson, G.W., 1966. An analysis of vendor selection systems and decisions, J. Purchasing, 2(1): 5-17.
11. Cheraghi, S.H., M. Dadashzadeh and M. Subramanian, 2004. Critical Success Factors For Supplier Selection: An Update. J. Appl. Business Res., 20(2): 91-108.
12. Triantaphyllou, E., 2000. Multi-Criteria Decision Making Methods: A Comparative Study (Kluwer Academic Publishers, Netherlands pp: 5-201.
13. Ho, W., X. Xu and P.K. Dey, 2010. Multi-criteria decision making approaches for supplier evaluation and selection: A literature review, Eu. J. O R., 202: 16-24.
14. Shih, H.S., H.J. Shyur and E.S. Lee, 2007. An extension of TOPSIS for group decision making, Math and Com. Mod., 45: 801-813.
15. Omayma, A.N., H.A. ElMaraghy and W.H. ElMaraghy, 2007. Quality prediction in manufacturing system design. J. Manufacturing Systems, 25(3): 153-171.
16. Michael, J.S and U. Menon, 1990. Knowledge-based manufacturing quality management: A qualitative reasoning approach. Decision Support Systems, 6(1): 59-81.
17. Marston, R.C., 1990. Pricing to market in Japanese manufacturing. J. International Economics, 29(3-4): 217-236.
18. Handfield, R.B. and R.T. Pannesi, 1992. An Empirical Study of Delivery Speed and Reliability. International J. Operations and Production Management, 12(2): 58-72.