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A New Framework for Evaluation and Prioritization of Suppliers using a Hierarchical Fuzzy TOPSIS

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Abstract**—**This paper suggests an algorithm for the evaluation and selection of suppliers. At the beginning, all the needed materials and services used by the organization were identified and categorized with regard to their nature by ABC method. Afterwards, in order to reduce risk factors and maximize the organization's profit, purchase strategies were determined. Then, appropriate criteria were identified for primary evaluation of suppliers applying to the organization. The output of this stage was a list of suppliers qualified by the organization to participate in its tenders. Subsequently, considering a material in particular, appropriate criteria on the ordering of the mentioned material were determined, taking into account the particular materials' specifications as well as the organization's needs.

Finally, for the purpose of validation and verification of the proposed model, it was applied to Mobarakeh Steel Company (MSC), the qualified suppliers of this Company are ranked by the means of a Hierarchical Fuzzy TOPSIS method. The obtained results show that the proposed algorithm is quite effective, efficient and easy to apply.

Keywords**—**ABC analysis, Hierarchical Fuzzy TOPSIS, Primary supplier evaluation, Purchasing strategy, supplier selection.

I. Introduction

A key and perhaps the most important process of the purchasing function is the efficient selection of vendors, because it brings significant savings for the organization [1].

While the traditional vendor evaluation methods primarily considered financial measures in the decision making process, more recent emphasis on manufacturing strategies such as just-in-time (JIT) has placed increasing importance on the incorporation of multiple vendor criteria into evaluation process [2].

The decision makers (DMs) always express their preferences on the alternatives or on the attributes of suppliers, which can be used to help rank the suppliers or select the most desirable one[3]. Consequently, we consider supplier selection as a multiple-attribute decision-making (MADM) problem.

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DM's judgments are often uncertain and cannot be estimated by an exact numerical value. Fuzzy Set Theory presents a framework for modeling the supplier selection problem in an uncertainty environment. In this theory, linguistic variables are used instead of crisp values. FST can be combined with other techniques to improve the quality of the final tools [4].

In this paper, we propose a Hierarchical approach for evaluation and selection of vendors in Mobarakeh Steel Company(MSC), using TOPSIS under uncertainty conditions. We also present an application that is programmed with MATLAB 6.5 to demonstrate results of this approach.

This paper is organized as follows. Section II presents an overview of supplier selection methods. Section III introduces the proposed algorithm using Fuzzy Topsis. An application (case study) based on the proposed algorithm is illustrated in section 4 and, finally, conclusions are given in Section V.

II. Literature Review

Researchers have focused on supplier selection problem since the 1960's. Benton and Krajewski[5] report on the impact of selecting a set of poor vendors. They conclude that the selection of poor vendors could lead to significant backlog and shortage in the quality of products delivered to customers [1].

Supplier selection decisions are very complicated because of various factors that must be considered in the decision-making process. Many researchers pointed out that the numbers and types of criteria totally depend on the corporate policy, objectives and strategy. Hence, in this paper, we defined specific factors with technical assistance of local managers to suit conditions in our case study.

The decision-making methods used in supplier selection problem are divided into 2 main categories: mathematical programming models and weighting models.

A simulation experiment by Zanakis et al, [6] evaluated eight MADM methods: SAW; multiplicative exponential weighting (MEW); technique for order preference by similarity to ideal solution (TOPSIS); elimination and choice translating reality (ELECTRE); and four analytical hierarchy processes (AHPs).

Finally, a number of authors suggest to use fuzzy sets theory (FST) to model uncertainty and imprecision in supplier choice situation. In short, FST offers a mathematically precise way of modeling vague preferences, e.g. when it comes to setting weights of performance scores on criteria [4].

Bellman and Zadeh[7] presented some applications of fuzzy theories to the various decision-making processes in a fuzzy environment. Zimmermann [8] presented a fuzzy optimization technique to linear programming (LP) problem with single and multiple objectives [9].

Morlacchi[10], Kahraman[11] and Noorul Haq[1] were some of the researchers who developed a model that combines Fuzzy Set Theory with AHP.

Technique for Order performance by Similarity to Ideal Solution (TOPSIS), one of the known classical MCDM methods, was first developed by Hwang and Yoon [12]. It is based upon the concept that the chosen alternative should have the shortest distance from the Positive Ideal Solution (PIS), i.e., the solution that maximizes the benefit criteria and minimizes the cost criteria; and the farthest from the Negative Ideal Solution (NIS), i.e., the solution that maximizes the cost criteria and minimizes the benefit criteria[13].

Based on the above literature, most of the previous researchers have focused mostly on selection methods. In this paper, we try to present a framework and apply it to an evaluation and selection process from beginning to the end, including classifying materials, defining suitable purchasing strategy, finding factors and selecting suppliers based on them.

III. Proposed Algorithm

Thus far, most of the different methods and hybrid techniques offered for evaluating and prioritizing suppliers focus on selection and solely rank the suppliers. Lee, Ha and Kim[14] offered effective supplier management process by combining AHP and Pareto. Ho, Ha and Krishman[15], also, presented a combination of NN, DEA, and AHP for analyzing purchase process. However, none of the researchers on this subject, have used a combination of ABC and fuzzy TOPSIS in choosing the suppliers. We present this framework in a five-step procedure that is shown in Fig. 1.

A. Classification of the Materials

ABC Analysis traditionally identifies the top 20% of the parts as the critical parts that account for approximately 80% of the total cost of purchase.

In this paper, all the needed materials and services used by the organization are identified and categorized with regard to their nature by ABC method. The purpose of such classification is to identify critical materials.

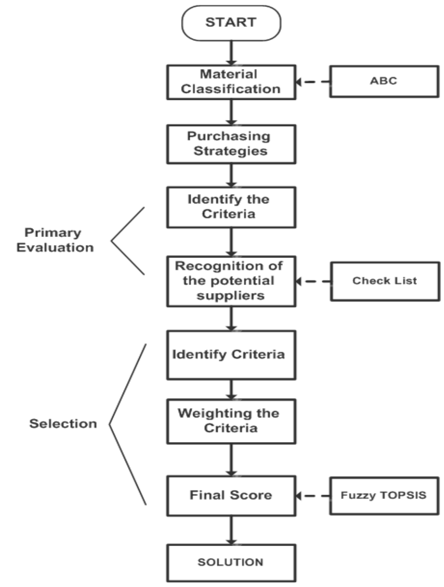

Fig. 1 Flow Chart of proposed Algorithm

The annual value (in dollars) for purchasing materials, $W(p)$, and the annual value portion for purchasing each material, $w(p)$, are calculated as:

$$W(p) = d_p \times k_p \tag{1}$$

$$w(p) = W(p) \Big/ \sum_{j=1}^{P} W(j) \tag{2}$$

Where, d_p is demand of material p and k_p is the cost of that material.

All materials are ranked based on their annual value portions. The material with highest value portion is given rank 1 and the material with lowest value portion is given rank P, where P is the number of materials. For graphical representation in a two-dimensional coordinate system, abscissa is the sorted materials starting from rank 1 and ordinate is the cumulative value portion.

$$\hat{w}(p) = \sum_{l=1}^{p} w(l) \tag{3}$$

B. Identification of Purchasing Strategy

Most of the organizations don't have a particular program to differentiate between their critical and none-critical materials. In order to minimize the purchase risk and maximize the profit, it is recommended that purchase process is combined with different strategies. These strategies are determined logically based on the results of ABC analysis and with regard to organization's strategies and its market.

C. Primary Evaluation

Suppliers applied for the organization are evaluated based on primary criteria (the general criteria concerning information and internal properties of suppliers) to determine whether they are qualified for supplying the materials, parts or even services of the organization or not. Those suppliers which have achieved the minimum rate will be accepted. This procedure is as follow:

C-1. Identification of Criteria for Primary Evaluation

In order to choose appropriate criteria, some workgroups are held. These workgroups consist of experts from operational and none-operational areas of organization who are aware of technical issues in their field of work. The employees who have experience of supplier evaluation, holding quality management systems, or auditing systems are preferred. The participants will get to most suitable criteria by talking over them in these groups.

C-2. Recognition of Potential Suppliers

In order to select potential suppliers among the ones which have undergone the primary evaluation, a primary evaluation check list will be prepared. All the suppliers will be evaluated based on the information given and a site visit if necessary; those who obtain a minimum score through this checklist will be accepted. Otherwise they will be refused but the areas in which suppliers could not get acceptable scores are announced to them. They can revise themselves and apply again if interested.

D. Selection

In the recent literature, some fuzzy TOPSIS methods were developed for vague environments. The classical TOPSIS methods do not have a hierarchical structure, and the only method that considers hierarchy between criteria and sub-criteria is AHP. In this paper, a Hierarchical Fuzzy TOPSIS is developed for a vendor selection problem.

D-1. Identification of Criteria

With the intention of choosing proper criteria for supplier selection, workgroups are held like the prior step; the only difference is that these workgroups will focus on internal needs of the organization. Moreover, we have to bear in mind that the aim in this step is to buy specific material so appropriate criteria taking into account its specifications and the organization needs are determined.

D-2. Calculation of Weights of Criteria

As apposed to primary evaluation step that some steady weights are defined for all criteria, no particular weight is determined in this step because the importance weight of criteria might be different in various orders (or even a specific purchase in various conditions). Consequently, it's better to weigh them individually for each order. To present weighting process, the importance weight matrix of criteria and sub-criteria are defined.

We assume that $\widetilde{w}_i$ is the weight of $i\,th$ criteria and $\widetilde{w}_{ij}$ is the weight of $j\,th$ sub-criteria of its associated criteria. We calculate final weight of each sub-criterion separately, by multiplying these two kinds of weights where $k = 1,2,...,m$ and m is the number of all sub-criteria.

$$\widetilde{W}_k = \widetilde{w}_i(.)\widetilde{w}_{ij} \tag{4}$$

As we use a triangular fuzzy number in this paper, the fuzzy weights are shown as follows:

$$\widetilde{w}_i = (\alpha_i, \beta_i, \delta_i) \text{ and } \widetilde{w}_{ij} = (\alpha'_i, \beta'_i, \delta'_i) \tag{5}$$
$$\widetilde{W}_k = (\alpha_i, \beta_i, \delta_i).(\alpha'_i, \beta'_i, \delta'_i) = (\alpha_i\alpha'_i, \beta_i\beta'_i, \delta_i\delta'_i)$$

D-3. Computation of Final Score

In this step, the decision makers evaluate potential suppliers based on fuzzy TOPSIS method and defined criteria. First a decision matrix, D, of dimension $n \times m$ is defined Where x_{ij} is rating of supplier A_i ($i = 1,2,....,\ n$) with considering sub-criteria C_j ($j = 1,2,...,\ m$). We assume x_{ij} as a fuzzy number presented by a triangular number $x_{ij} = (a_{ij}, b_{ij}, c_{ij})$.

$$\begin{array}{cc} & \begin{matrix} C_1 & C_2 & \dots & C_m \end{matrix} \\ D = \begin{matrix} A_1 \\ A_2 \\ \\ A_n \end{matrix} & \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1m} \\ x_{21} & x22 & \dots & x_{2m} \\ & & & \\ x_{n1} & x_{n2} & & x_{nm} \end{bmatrix} \end{array} \tag{6}$$

In order to make an easy procedure similar to Saghafian and Hejazi [13], all fuzzy numbers in our model are defined in close interval [0,1] so the normalized decision matrix is obtained directly. The weighted normalized fuzzy decision matrix is calculated as:

$$v_{ij} = x_{ij}(.)\widetilde{W}_k \tag{7}$$
$$V = [v_{ij}]_{k \times m}$$

We use Lee and Li's ranking method [16], to determine fuzzy positive ideal solution and fuzzy negative ideal solution. This method is so useful for comparison of fuzzy numbers. In this ranking procedure, generalized mean of all fuzzy numbers in V matrix are calculated.

$$M(v_{ij}) = (-a^2 + c^2 - ab + bc) \big/ [3(-a+c)] \tag{8}$$

The results are all crisp and are defined as A^* and A^-. v_j^* and v_j^- are the fuzzy numbers with the largest generalized mean and the smallest generalized mean, respectively.

$$A^* = [v_1^*, ..., v_n^*] \tag{9}$$
$$A^- = [v_1^-, ..., v_n^-]$$

The distance of each supplier A_i ($i = 1,2,....,n$) from A^* and A^- is calculated by using Vertex method as follows:

$$d_i(v_{ij}, v_j^*) = \sum_{j=1}^{n} \left[\tfrac{1}{3}((a_{ij} - a_j^*)^2 + (b_{ij} - b_j^*)^2 + (c_{ij} - c_j^*)^2) \right]^{0.5} \tag{10}$$
$$d_i(v_{ij}, v_j^-) = \sum_{j=1}^{n} \left[\tfrac{1}{3}((a_{ij} - a_j^-)^2 + (b_{ij} - b_j^-)^2 + (c_{ij} - c_j^-)^2) \right]^{0.5}$$

The closeness coefficient of each supplier is computed as follows:

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$$CC_i = \frac{d_i(v_{ij}, v_j^-)}{d_i(v_{ij}, v_j^-) + d_i(v_{ij}, v_j^*)} \qquad (11)$$

All suppliers are ranked in a descending order. The larger the index value, the better the performance of supplier.

IV. Implementation

In this section, we describe how vendor selection decisions are made using the presented framework. This framework has been applied to Mobarakeh Steel Company (MSC), the largest industrial complex in the Islamic Republic of Iran that has an annual capacity of 4 mt/years of flat steel products in the form of hot and cold rolled coils and sheets, tinplate sheets and coils, Galvanized and preprinted coils.

In the beginning, an overall identification of purchasing process, its critical and reformable points were obtained by interviewing and studying all related documents. The point is that in all bids, the supplier which has offered lower price is accepted. New purchasing policies of organization are determined according to the selection of appropriate suppliers considering suitable criteria. It makes the organization to decrease its tied-up capital and hence, they are interested in changing the purchasing process and use the proposed method.

A. Classification of Materials

All the needed materials and services used by the organization are identified and categorized with regard to their nature into 4 main groups as below:

- Raw Materials: consisting of 12 sub-groups
- Spare parts and equipments: consisting of 11 sub-groups
- Consumer goods: consisting of 13 sub-groups
- Services: consisting of 15 sub-groups

Raw material group is chosen for examining the proposed framework. The financial accounts of year 2006 and 2007 were used for classifying these materials into A, B and C. All calculations are based on average of these two years and shown in Table I.

The result of this classification is shown in Fig. 1 as an ABC curve, and Table II presents materials listed in A, B, and C classes. Class A consists of Scrap, Iron ore, materials and semi materials. It indicates that 25% of all materials consist approximately 74% of total annual value that organization spends for buying them. These items are so valuable and require special care and strict control. Items in class B include 25% of all items and around 17% of total annual value, and at last items in class C, 50% of items and less than 9% of total annual value. For B items, moderate control should be used but C items are least important ones because of low price or low demand.

TABLE I
RANKED RAW MATERIAL BY VALUE PORTIONS

Row	Material Group	$W(p)$	$w(p)$	Rank
1	Iron Ore	286.5	0.29134	2
2	Additives & Fluxes Including	26.7	0.02715	7
3	Carburizing materials	11.95	0.01215	10
4	Ferro-alloy	57	0.05797	5
5	Metals and semi metals	124.7	0.12682	3
6	Scrap	314.35	0.31966	1
7	Gas	0.194	0.0002	12
8	Slab	10.24	0.01041	11
9	Refractory Materials	49.75	0.05059	6
10	Graphite Electrode	65.7	0.06681	4
11	Industrial chemical products	23.94	0.02434	8
12	Industrial Lubricant	12.35	0.01256	9
		983.374		

TABLE II
RAW MATERIAL CLASSIFICATION BY CUMULATED VALUE PORTIONS

Material Group	Rank	ŵ	Class
Scrap	1	0.31966	A
Iron Ore	2	0.61100	
Metals and semi metals	3	0.73782	
Graphite Electrode	4	0.80463	B
Ferro-alloy	5	0.86260	
Refractory Materials	6	0.91319	
Additives & Fluxes Including	7	0.94034	C
Industrial chemical products	8	0.96468	
Industrial Lubricant	9	0.97724	
Carburizing materials	10	0.98939	
Slab	11	0.9998	
Gas	12	1.0	

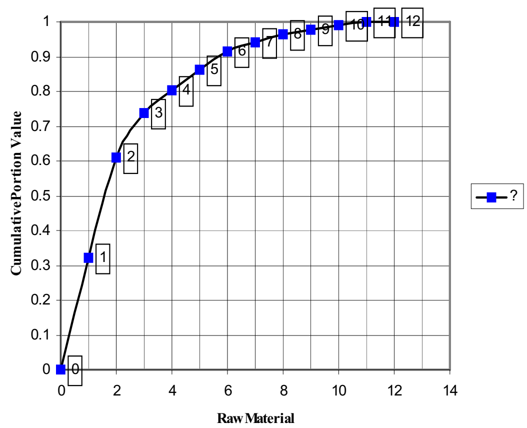

Fig. 2 ABC Curve

B. Identification of the Purchasing Strategy

As it said, class A has too much importance and, thus, suitable strategies must be designed for managing them in the best way. The question is how many suppliers the organization has to deal with. Organization should try to decrease number of suppliers as much as possible and hold long-term supply relationships instead. Here, we should consider two important issues first, the organization is better to avoid dealing with a single-supplier in order not to get into trouble especially in the case of emergencies. Second, it should not deal with too many suppliers because the situation may get out of control.

Since C items have low usage value, it's more economic to make their supplier selection as simple as possible, hence the money and time spent minimum. Therefore, it's preferred to use local suppliers and short term contracts. These items are better to be ordered annually and from single-source to decrease order costs.

C. Primary Evaluation

C-1. Identification of Suitable Criteria

Raw Material group is divided into 3 general parts: traders, retailers and producers. As the criteria defined for each part may differ partly, we decided to develop a primary evaluation checklist for just raw material producers. These criteria are shown in Table III.

C-2. Recognition of the potential Suppliers

Among all the suppliers which applied for the company, and were evaluated based on the information given and a site visit if necessary; those who obtain at a score of 75 or above through primary evaluation raw material checklist will be accepted. Only the accepted suppliers are included in Selection step.

D. Selection

Whenever MSC plans to buy a specific material, all the potential suppliers defined for this item are evaluated. In this paper, we chose A class item Scrap as one of the most important and effective materials for manufacturing process of company in order to examine proposed algorithm and compare and prioritize its potential suppliers.

D-1. Identification of Criteria

The criteria defined here, are only applicable for Scrap and consider internal needs of company. These criteria are shown in Table IV.

D-2. Weighting the Criteria

Linguistic variables for fuzzy weighting criteria are shown in Table V.

The hierarchical fuzzy TOPSIS presented here has two levels. The first level consists of 4 main criteria and the second level has 10 sub-criteria. The importance weight of criteria and sub-criteria are represented in Table VI and VII respectively.

D-3. Computation of Final Score

TABLE III
CRITERIA FOR PRIMARY EVALUATION OF RAW MATERIAL SUPPLIERS

Criteria	Weight	Sub-Criteria	Weigh
1.Financial Position	25	1.1. Annual Turnover	100
2.Performance History	10	2.1. Quality of delivered orders	25
		2.2. After sale services quality	15
		2.3. On-time commitments	20
		2.4.Relative History	30
3.Standards and Relevant Certificates	15	3.1. Equipment calibration audit	25
		3.2. ISO 9001:2000	35
		3.3. Scientific and technical certificate relevant to activities	15
		3.4. ISO 14001:2004	10
		3.5. OHSAS 18001:1999	15
4.Production Specifications	30	4.1. Nominal production capacity	35
		4.2. Process out sourcing percentage	10
		4.3. Equipment Mechanism percentage	15
		4.4. number of working shifts	10
		4.5. Buffer capacity	20
		4.6. Tools ownership	10
5.Commerial Strength	15	5.1. To have a license of a valid company	30
		5.2. Place of Material delivery	40
		5.3. Inventory system	30
6.General Factors	5	6.1. Innovation relative to activities	20
		6.2. Information systems, software and hardware facilities	25
		6.3. Level of literacy of key employees	35
		6.4. properties	20

TABLE IV
CRITERIA FOR SCRAP SUPPLIER SELECTION

Criteria	Sub-Criteria
Quality specifications	quality
	Ability to improve quality
Expenditure specifications	Order price
	Transportation cost
	Payment and Discount conditions
supply	On-time delivery
	Proper distribution capacity
Organizational knowledge	Knowledge level
	Relevant background
	Personnel's skill

TABLE V
THE LINGUISTIC VARIABLES FOR WEIGHTING EACH CRITERION

Linguistic Variables	Fuzzy Numbers
Very Low(VL)	(0,0,0.2)
Low(L)	(0.1,0.2,0.3)
Medium Low(ML)	(0.2,0.3,0.4)
Medium(M)	(0.35,0.5,0.65)
Medium High(MH)	(0.6,0.7,0.8)
High(H)	(0.7,0.8,0.9)
Very High(VH)	(0.8,1,1)

TABLE VI
THE IMPORTANCE WEIGHT OF EACH CRITERION FOR CASE STUDY

Criteria	Weight
Quality specifications	(0.7,0.8,0.9)
Expenditure specifications	(0.8,1,1)
supply	(0.1,0.2,0.3)
Organizational knowledge	(0.35,0.5,0.65)

TABLE VII
THE FINAL IMPORTANCE WEGHT OF EACH CRITERION FOR CASE STUDY

Sub-Criteria	Weight
quality	(0.49,0.64,0.81)
Ability to improve quality	(0.42,0.56,0.72)
Order price	(0.56,0.80,0.90)
Transportation cost	(0.48,0.70,0.08)
Payment and Discount conditions	(0.28,0.50,0.65)
On-time delivery	(0.07,0.16,0.27)
Proper distribution capacity	(0.06,0.14,0.24)
Knowledge level	(0.25,0.40,0.59)
Relevant background	(0.12,0.25,0.42)
Personnel's skill	(0.07,0.15,0.26)

There are 5 scrap potential suppliers A_i (i=1,2,…,5) compared against 10 factors (defined in previous step) based on linguistic variables presented in Table VIII.

At last the weighted normalized fuzzy matrix is shown in table IX.

The Fuzzy Positive Ideal Solution and Fuzzy Negative Ideal Solution are calculated Refer to (10) and also the distance of each candidate from FPIS and FNIS are calculated respectively using Refer to (11). The closeness coefficient is calculated for each supplier using Refer to (12) and the results are as follows:

$$CC_1 = 0.39678, CC_2 = 0.43344, CC_3 = 0.40153$$

$$CC_4 = 0.36781, CC_5 = 0.62663$$

The results indicate that the prioritizing orders of suppliers are A_6, A_2, A_3, A_1, A_5. Three suppliers A_6, A_2, A_3 are chosen based on purchasing strategies of MSC.

TABLE VIII
THE LINGUISTIC VARIABLES FOR THE RATINGS

Linguistic Variables	Fuzzy Numbers
Very Poor(VP)	(0,0,0.2)
Poor (P)	(0.1,0.2,0.3)
Medium Poor (MP)	(0.2,0.3,0.4)
Fair(F)	(0.35,0.5,0.65)
Medium Good(MG)	(0.6,0.7,0.8)
Good(G)	(0.7,0.8,0.9)
Very Good(VG)	(0.8,1,1)

V. CONCLUSION

In this paper, we presented a framework to deal with supplier selection and evaluation problem that consists of 4 parts: Classifying the materials, Developing a purchasing strategy, Primary and Final evaluation of suppliers.

The benefits, MSC obtained by implementing this framework are:

Company found a way to identify key and critical materials by classifying all materials and their suppliers based on their nature. As very strict controls should be placed on critical materials, appropriate purchasing strategies were defined for procuring them. These strategies make the probability of downtime and its detriments become much more less than before.

Primary evaluation had 2 valuable benefits for MSC. Firstly, the company which had an imperfect and weak supplier archive, started to gather supplier Information (on the past and new ones) including properties Brochures, catalogs, technical documents, fields of activity, all materials they can provide and other general information. Secondly, standardized conditions were defined for all tenders so suppliers who are under this level have no chance to be considered in selection step. In case of acceptance, suppliers are accredited for the company.

Mobarakeh Steel Company successfully defined effective criteria for every Class (by considering specifications of that class), and used a Hierarchical Fuzzy TOPSIS for handling

TABLE IX
THE FINAL RESULTS

	quality	Ability to improve quality	Order price	Transportation cost	Payment and Discount conditions
A_1	(0.17,0.32,0.53)	(0.04,0.11,0.22)	(0.11,0.24,0.36)	(0.17,0.35,0.52)	(0.03,0.1,0.2)
A_2	(0.17,0.32,0.53)	(0.30,0.44,0.64)	(0.00,0.00,0.18)	(0.10,0.21,0.32)	(0.1,0.25,0.42)
A_3	(0.30,0.44,0.64)	(0.04,0.11,0.22)	(0.06,0.16,0.27)	(0.17,0.35,0.52)	(0.03,0.1,0.2)
A_4	(0.30,0.44,0.64)	(0.08,0.17,0.29)	(0.20,0.40,0.59)	(0.05,0.14,0.24)	(0.06,0.15,0.26)
A_5	(0.17,0.32,0.53)	(0.00,0.00,0.14)	(0.34,0.56,0.72)	(0.29,0.49,0.64)	(0.1,0.25,0.42)
	On-time delivery	Proper distribution capacity	Knowledge level	Relevant background	Personnel's skill
A_1	(0.01,0.05,0.11)	(0.02,0.07,0.16)	(0.2,0.4,0.59)	(0.04,0.13,0.27)	(0.04,0.11,0.21)
A_2	(0.01,0.03,0.08)	(0.01,0.04,0.10)	(0.15,0.28,0.47)	(0.07,0.18,0.34)	(0.05,0.12,0.23)
A_3	(0.01,0.05,0.11)	(0.04,0.10,0.20)	(0.09,0.2,0.38)	(0.08,0.2,0.38)	(0.06,0.15,0.26)
A_4	(0.05,0.13,0.25)	(0.02,0.07,0.16)	(0.05,0.12,0.24)	(0.04,0.13,0.27)	(0.05,0.12,0.23)
A_5	(0.02,0.08,0.18)	(0.05,0.14,0.24)	(0.09,0.2,0.38)	(0.08,0.2,0.38)	(0.02,0.08,0.17)

uncertainty and improve quality of selecting best suppliers with considering both qualitative and quantitative criteria.

The old system was set only on price but the new one promoted decision-making process in M.S.C by proposing a more precise way. Here is not only the price but many other criteria are the basis for the selection of a potential supplier. It should be noted that the proposed algorithm was quite reliable and more efficient than the old systems.

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