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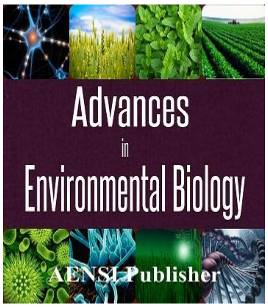

Ranking suppliers using QFD/FAHP method

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ABSTRACT

The process of choosing supplier is the most important variable in effective management of modern supply chain, because it contributes achieving high quality products and satisfied customers. An effective supplier selection needs strong analysis models and decision making support equipment in order to create balance between subjective and objective multi-factor criteria. Also it is important to mention that most of producer organizations face more than one criterion in order to choose a supplier. In the present research, we present a combined method for selecting the best supplier in order to rank customer features and use quality operational function. In this research, first the technical features were identified in order to select the suppliers. Then, the importance level of each supplier was obtained after taking into consideration the opinions of professionals and experts presented in the research process and using combined approach of QFD & FAHP. In order to examine the efficiency of the presented method, it was implemented in a pharmaceutical company in Shiraz. The results of data analysis show that the first supplier with relative importance of 0.379 was first in priority and the third supplier with relative importance of 0.272 was the third. In final sections of the present research we present shortages and limitations, practical and research suggestions.

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INTRODUCTION

Because trusted suppliers enable producers to decrease the price of products and increase the quality, this can be understood that producers are increasingly concerned about selection of supplier and it is clear that selecting appropriate suppliers and effective communication management with supplier is a key factor in increasing compatibility of companies. Along with implementation of this philosophy, selecting a supplier in supply chain model is considered as an important matter which moves decision makers toward using techniques and valid methods in order to select a supplier [3]. The suppliers are a complementary part of supply chain process of an organization and managing suppliers needs professional negotiation skills because they are not considered as a part of organization. The suppliers should be selected wisely, because they will have strongly positive or negative effects on general operation of an organization. Different researches show that the problems pertaining to product quality in organizations are resulted from defective raw material. Accuracy in supplier selection can minimize the negative effects and increase the positive effects on the quality of an organization gains [15]. So, selecting an appropriate supplier is a crucial part of organization structure. It is worth to mention that old and conventional methods of selection and evaluation of suppliers often ignore a large part of criteria due to lots of reasons. But the major reason for that is related to conventional operation evaluation system. In fact we can claim that these evaluation methods are usually based on price or are initially based on price or qualitative evaluation of operation which were used unconditionally through matrix methods. In such cases, the manager faces valuable information shortages in order to evaluate and select the suppliers' operation. At this time the necessity of using modern approaches will emerge in selection and evaluation processes. So, in supply chain management, having an appropriate pattern is necessary in order to evaluate and choose an appropriate supplier among the alternatives. Hence, the main concern of this research is to present a comprehensive pattern

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of effective indices in order to evaluate and wisely select the supplier. There are lots of methods presented so far which can be used to evaluate and choose suppliers. Most of these methods try to choose the best among different alternatives. To do that, in the present research we present a method combined of "Quality Function Deployment ", "fuzzy series theory", and "Fuzzy Analytic Hierarchy Process" in order to rank and evaluate the suppliers. So we extracted certain characteristics of organization and technical features of suppliers using "Quality Function Deployment" in order to estimate customer's characteristic. Ranking the technical features is done using "Fuzzy Analytic Hierarchy Process ". In order to weigh customer's characteristics and technical features we use experts' opinions. Their opinions were collected using questionnaires in form of verbal variables and converted to fuzzy numbers using special tables. Fuzzy numbers used in the present research are triangular fuzzy numbers. We can use this method both for producer organizations and service providers. Also, there is no limitation in the number of decision makers and features and it can cover qualitative and quantitative indices. It is worth mentioning that we can use this method in order to select new suppliers and also to rank the existing suppliers.

Theoretical background and literature review:

"Competition" is a completely known term in complicated world today. Decreasing the final price, increasing the level of serving customers, quickly meeting customers' needs, increasing the quality of product and the presented services to customers are among factors which are necessary in order to survive in competition for every product and presented service. So, in recent years the term "supply chain" was formed in order to decrease the expenses as far as possible and meanwhile increase the quality of products and services presented to customers by creating different parts of producing and distributing goods or services and the so called effective management of supply chain. Managing the supply chain is in charge of integrating organization units in supply chain length and arranging material, financial and data flow in order to meet the requirements of end customers aiming at supply compatibility. Today's highly competitive markets force companies to quickly and accurately meet the customers' needs. In this way they maintain and improve their position and status in their markets through satisfying customers [6]. Such pressures force companies to invest on implementation of concepts such as comprehensive quality management and on-time reaction. Is such a situation, the role of suppliers and related discussions in supplier chain management receives high importance. Organizations find survival secret in meeting customers' needs. Interests and needs of customers may include decreasing price, on-time transportation, approving quality and so on [5]. After introducing criteria, methods and models used in choosing suppliers, it is time to investigate the related researches and studies with the present study and domestic researches. Among related researches carried out, we can name some as following:

Ghodsypour and Brien [3] integrated hierarchical data analysis process with linear programming in order to decrease the number of suppliers based on supply – oriented optimization strategy and considering qualitative and quantitative, obvious and abstract factors simultaneously in purchase activity and aiming at optimization of placing order among suppliers. Xia and Wu [21] integrated hierarchical analysis process of optimized data by uneven series theory with programing of motley integer in order to simultaneously determine the number of suppliers and to specify orders among them in multi-factor source finding mode, existing several goods, several criteria and considering supplier limitations. They assumed in their model that the basis of quantity or variety is the purchased products. They presented solved algorithm and two numeral examples for more explanation on model. Cebiand Bayraktar also integrated lexicographic ideal programming and hierarchical data analysis process in order to specify orders among suppliers. The purpose of their model was to maximize the quality level of purchased products, to minimize price function and to maximize approving function. The limitations under the study included complete satisfaction of customers' needs, meeting maximum and minimum of order volume for each supplier and each item. The criteria they used involved logistic criteria, technologic criteria, commercial and communicative criteria. Sarciss and Talory suggested using network analysis method in order to select supplier but no author had used this method in order to choose a supplier. A research carried out by Teymouri titled "developing the model for supplier selection and distribution with supply chain management viewpoint". The researcher investigated two major activities in supply management and presented a mathematical model according to existing research gaps in order to optimize them. These two activities are: selection and presentation of suppliers as a member in supply chain and distribution of existing items in central stock via peripheral warehouses. In this research, integrated mathematical models are presented in order to select preferred suppliers and to simultaneously promote them if necessary. On the other hand, the model presented by the researcher also investigated optimum distribution of items [19]. In another research carried out by Riazi, he presented a step by step approach to choose supplier emphasizing on the strategic importance of purchase in prosperity of a company. In this approach, the relation between selecting suppliers and macro strategies of company are considered. Among the strong points of the mentioned research, we can name its process based and integrated view point. The researcher distinguishes the process of selecting the supplier from identification of the supplier and then, according to the selected criteria, classified the appropriate, extendable and inappropriate suppliers. In each step, if a mathematic model is necessary, a certain model is designed and used.

Safarkhanlou [16] in his thesis titled as "evaluation of smithereens suppliers' operation using fuzzy data covering analysis approach" evaluate the suppliers of *Irankhodro Company*. In this research, one of special models of data covering analysis named as fuzzy weights shared series model was used in order to evaluate the function of 29 motor parts suppliers in *Sapco Company* in 2004. He strategically emphasized on identifying inefficient units and organizing them under efficient units aiming at decreasing expenses and improving supplier selection management [16]. Rahnamay Kamsari in another thesis titled as identification, composition andranking criteria for function evaluation of supply chain using multi – factor decision making carried out in *Panberes Company* suppliers collection, after determining the function evaluation of suppliers' function which were extracted according to previous researches and asking the opinion of professionals, TOPSIS and AHP techniques were used for their ranking [14]. Mehreganfar [12] in his MA thesis titled as "evaluation of ranking techniques of smithereens suppliers in automobile industry, determined the importance of each, using MCDM in fuzzy environment after identification of major and sub criteria using Fuzzy Analytic Hierarchy Process. Then the suppliers were ranked with two methods of hierarchical analysis and fuzzy topsis.Hosseinpour evaluated smithereens suppliers' of Isaco Company using fuzzy topsis technique. In this research, after identification of criteria, their weights were determined by Shannon entropy method and then the suppliers were ranked using SAW and TOPSIS techniques. Finally using priority combination strategies, ranks of one unit of suppliers were presented.

Research Method:

The present research is practical in terms of purpose of the study and data collection method is descriptive method. In this research we present a method that is a combination of "Quality Function Deployment", "fuzzy series theory", and "Fuzzy Analytic Hierarchy Process " in order to rank and evaluate the suppliers. In order to do this, we extracted the features of a certain organization and technical features of suppliers using "Quality Function Deployment" in order to estimate customer's characteristics. Ranking technical features carried out using "Fuzzy Analytic Hierarchy Process ". We used experts' opinion in order to weight customers' characteristics and technical features. The remarks of the experts were collected by questionnaires in form of verbal variables and were converted in fuzzy numbers using special tables. The fuzzy numbers used in the present research were triangular fuzzy numbers. Statistical population of the present research involved all professionals and experts in pharmaceutic industry and university professors who could participate in the required tests for case studies. On order to select samples among expert for this participation we used judicative purposeful sampling. This research was carried out in the field of selecting suppliers during 2013 in Shiraz.

Quality Function Deployment:

Quality function deployment is strong equipment for increasing customer's satisfaction through developing the quality of products and decreasing production time and expenses. The main philosophy of using quality function deployment is imposing qualitative needs of customer in different stages of product design. So all design features and characteristics of product are obtained according to view points of customer. In the initial stage of all common methods for Quality Function Deployment we use a matrix named quality house in which the needs of customer are imposed on engineering features. Quality function deployment process is a tool for extraction of needs and necessities of customers and classification of these needs. This classification contributes organization to give primacy to customers' needs by a decision making process. This method truncates the growth path of product and largely optimizes deployment stages. It is very important for organizations for which aspect of product they should spend their capital in order to profit from sale market.

Fuzzy Analytic Hierarchy Process:

Methodology of Fuzzy Analytic Hierarchy Process is based on fuzzy series theory – presented by professor Lotfi in 1965. Fuzzy Analytic Hierarchy Process, expands AHP combining it with fuzzy series theory. In Fuzzy Analytic Hierarchy Process, after creating hierarchical structure for the question to be solved, we use fuzzy relative scales in order to illustrate relative importance of factors corresponding with criteria. Hence we create a fuzzy judicative matrix, present final points of alternatives using fuzzy numbers and obtain the optimum alternative through ranking fuzzy numbers using special algebraic agents.

Data analysis:

In order to analysis the data, observation of steps below is necessary.

Step one- determination of needs and requirements of customers:

In this section we identified a rather comprehensive list of customer's required features presented in table1 below.

Table 1: Customer's required features in the present case study.

symbol	Customer's required features	symbol	Customer's required features
C_1	Technical information	C_7	Amount of discount
C_2	Technical services	C_8	Organizational culture
C_3	Delicacy of research and deployment	C_9	Company's reputation
C_4	Certificate of supplier	C_{10}	History of company's operation
C_5	Financial capacities	C_{11}	Transportation
C_6	External environment		

Step two- creating hierarchical tree for the question:

The identified features of customer are classified in a general framework named classification main factors. As a result the hierarchical structure under the case study is presented in figure 1 below.

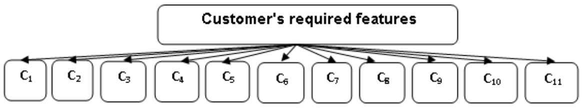

Fig. 1: Hierarchical tree.

Step three- definition of triangular fuzzy numbers:

In this step we need to build pair comparison matrixes. Gathering the opinions of participants is carried out in form of verbal variables and 6 – item LIKERT scale. Then we can convert the verbal variables into triangular fuzzy numbers based on table2.

Table 2: Triangular fuzzy numbers (Wu *et al*, 2007).

Verbal variables	Fuzzy numbers
Exactly similar	(1, 1, 1)
Relatively similar	(0.5, 1, 1.5)
Weak	(1, 1.5, 2)
Relatively important	(1.5, 2, 2.5)
Very important	(2, 2.5, 3)
Absolutely important	(2.5, 3, 3.5)

Step four- pair comparisons:

In Fuzzy Analytic Hierarchy Process, relative importance of indices and alternatives is obtained doing pair comparisons. In this stage, according to experts' opinions and using mentioned fuzzy numbers, the relative importance of indices are obtained compared to each other according which we can create pair comparison matrix $\tilde{A}'$ as below, in which $\tilde{a}'_{ij}$ is a triangular fuzzy number and indicates relative importance of i^th^ index compared to j^th^ index.

$$\tilde{A}=\begin{bmatrix} \tilde{a}'_{11} & \tilde{a}'_{12} & . & . & \tilde{a}'_{1n} \\ \tilde{a}'_{21} & . & . & . & . \\ . & . & . & . & . \\ . & . & . & . & . \\ \tilde{a}'_{n1} & . & . & . & \tilde{a}'_{nn} \end{bmatrix} \quad , \quad \tilde{a}'_{ij}=\frac{1}{\tilde{a}'_{ji}}$$

Regarding the hierarchical structure obtained from the present case study, pair comparison matrixes are created using experts' opinions. Only the pair comparison matrix is implied by the first expert among the main methods related to the purpose in terms of high volume calculations (table3).

Step five- judicative matrix creation:

In order to merge the opinions we use the terms below to create judicative matrix.

$$L_{ij}=\sqrt[n]{\prod_{k=1}^{n} L_{ijk}} \quad , \quad M_{ij}=\sqrt[n]{\prod_{k=1}^{n} M_{ijk}} \quad , \quad U_{ij}=\sqrt[n]{\prod_{k=1}^{n} U_{ijk}}$$

Judicative matrix is created by merging pair comparison matrixes through geometrical mean calculation of experts' opinions. Table 4 illustrates judicative matrix.

Table 3: Pair comparison matrixes among indices related to the purpose by the expert DM_1.

D1	C_1			C_2			C_3			C_4			C_5			C_6			C_7			C_8			C_9			C_{10}			C_{11}		
C_1	1.0	1.0	1.0	0.5	1.0	1.5	0.5	0.7	1.0	0.5	1.0	1.5	1.0	1.0	1.0	0.5	0.7	1.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	0.7	1.0	0.3	0.3	0.4	0.7	1.0	2.0
C_2	0.7	1.0	2.0	1.0	1.0	1.0	2.5	3.0	3.5	0.7	1.0	2.0	2.5	3.0	3.5	0.3	0.4	0.5	0.7	1.0	2.0	2.5	3.0	3.5	0.3	0.4	0.5	0.7	1.0	2.0	1.0	1.5	2.0
C_3	1.0	1.5	2.0	0.3	0.3	0.4	1.0	1.0	1.0	0.3	0.3	0.4	1.0	1.0	1.0	1.0	1.0	1.0	0.3	0.3	0.4	0.5	1.0	1.5	2.0	2.5	3.0	0.3	0.3	0.4	0.3	0.4	0.5
C_4	0.7	1.0	2.0	0.5	1.0	1.5	2.5	3.0	3.5	1.0	1.0	1.0	0.3	0.4	0.5	0.7	1.0	2.0	0.5	0.7	1.0	0.5	1.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.7	1.0
C_5	1.0	1.0	1.0	0.3	0.3	0.4	1.0	1.0	1.0	2.0	2.5	3.0	1.0	1.0	1.0	0.5	1.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.3	0.4	0.5	0.3	0.3	0.4
C_6	1.0	1.5	2.0	2.0	2.5	3.0	1.0	1.0	1.0	0.5	1.0	1.5	0.7	1.0	2.0	1.0	1.0	1.0	2.5	3.0	3.5	0.5	1.0	1.5	0.7	1.0	2.0	1.0	1.5	2.0	1.0	1.5	2.0
C_7	0.7	1.0	2.0	0.5	1.0	1.5	2.5	3.0	3.5	1.0	1.5	2.0	1.0	1.0	1.0	0.3	0.3	0.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	2.0	2.5
C_8	0.3	0.3	0.5	0.3	0.3	0.4	0.7	1.0	2.0	0.7	1.0	2.0	1.0	1.0	1.0	0.7	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	0.7	1.0	2.0	0.7	1.0	2.0	0.5	0.7	1.0
C_9	1.0	1.5	2.0	2.0	2.5	3.0	0.3	0.4	0.5	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.5	1.0	1.0	1.0	0.5	1.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	0.4	0.5	0.7
C_{10}	2.5	3.0	3.5	0.5	1.0	1.5	2.5	3.0	3.5	1.0	1.0	1.0	2.0	2.5	3.0	0.5	0.7	1.0	1.0	1.0	1.0	0.5	1.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	0.3	0.4	0.5
C_{11}	0.5	1.0	1.5	0.5	0.7	1.0	2.0	2.5	3.0	1.0	1.5	2.0	2.5	3.0	3.5	0.5	0.7	1.0	0.4	0.5	0.7	1.0	1.5	2.0	1.5	2.0	2.5	2.0	2.5	3.0	1.0	1.0	1.0

Table 4: Judicative matrix of main indices related to the purpose.

	C_1			C_2			C_3			C_4			C_5			C_6			C_7			C_8			C_9			C_{10}			C_{11}		
C_1	1.00	1.00	1.00	1.24	1.30	1.69	0.86	1.25	1.58	0.81	1.08	1.43	1.19	1.37	1.73	0.71	0.83	1.18	0.90	0.98	1.17	0.87	1.21	1.59	1.10	1.24	1.59	0.65	1.00	1.34	1.08	1.43	1.92
C_2	0.59	0.77	0.81	1.00	1.00	1.00	0.58	0.86	1.22	0.82	1.08	1.54	0.96	1.17	1.50	0.65	0.80	1.07	0.68	0.90	1.22	0.87	0.98	1.19	0.70	0.98	1.25	0.72	0.99	1.36	0.80	1.14	1.53
C_3	0.63	0.80	1.17	0.82	1.17	1.72	1.00	1.00	1.00	0.71	0.88	1.21	0.75	1.00	1.36	0.98	1.22	1.56	0.64	0.75	0.95	0.57	0.74	1.09	1.12	1.26	1.44	0.47	0.59	0.77	0.81	1.08	1.42
C_4	0.70	0.92	1.23	0.65	0.93	1.21	0.83	1.13	1.41	1.00	1.00	1.00	0.49	0.63	0.87	0.92	1.16	1.56	1.02	1.48	1.96	0.65	0.84	1.08	0.96	1.18	1.51	0.86	0.92	1.05	0.90	1.23	1.68
C_5	0.58	0.73	0.84	0.67	0.85	1.04	0.74	1.00	1.33	1.16	1.59	2.03	1.00	1.00	1.00	0.74	1.02	1.39	0.55	0.77	1.05	0.49	0.65	0.94	0.65	0.80	1.06	0.66	0.95	1.28	0.71	0.89	1.10
C_6	0.85	1.20	1.41	0.93	1.25	1.54	0.64	0.82	1.02	0.64	0.86	1.09	0.72	0.98	1.34	1.00	1.00	1.00	0.72	0.92	1.27	0.78	1.05	1.45	0.87	1.22	1.81	0.62	0.85	1.14	0.85	1.11	1.46
C_7	0.85	1.02	1.11	0.82	1.11	1.47	1.05	1.34	1.57	0.51	0.68	0.98	0.95	1.30	1.82	0.79	1.09	1.39	1.00	1.00	1.00	0.65	0.87	1.05	0.53	0.71	0.99	0.87	1.09	1.38	0.53	0.80	1.16
C_8	0.63	0.83	1.15	0.84	1.02	1.16	0.92	1.35	1.76	0.93	1.19	1.55	1.06	1.53	2.02	0.69	0.95	1.28	0.95	1.15	1.54	1.00	1.00	1.00	0.69	0.91	1.35	0.70	0.91	1.34	0.69	1.07	1.43
C_9	0.63	0.80	0.91	0.80	1.02	1.43	0.70	0.79	0.89	0.66	0.85	1.04	0.95	1.24	1.54	0.55	0.82	1.15	1.01	1.40	1.90	0.74	1.10	1.46	1.00	1.00	1.00	0.67	0.83	1.21	0.73	0.92	1.19
C_{10}	0.75	1.00	1.54	0.73	1.01	1.40	1.29	1.69	2.14	0.95	1.08	1.17	0.78	1.05	1.51	0.88	1.18	1.62	0.72	0.92	1.15	0.75	1.10	1.43	0.83	1.21	1.50	1.00	1.00	1.00	0.70	0.94	1.30
C_{11}	0.52	0.70	0.93	0.65	0.88	1.24	0.70	0.92	1.23	0.59	0.81	1.11	0.91	1.13	1.41	0.69	0.90	1.17	0.86	1.25	1.90	0.70	0.94	1.46	0.84	1.09	1.38	0.77	1.07	1.43	1.00	1.00	1.00

Step six- calculation of weights of judicative matrix:

After creating judicative matrix, we should calculate the weights of each judicative matrix. In order to do that, we used Chang deployment analysis method. Table 5 illustrates the steps of Chang deployment analysis method.

In the present research we used Chang deployment and analysis method in order to calculate the initial fuzzy weights. To do this, we first calculate the sum of fuzzy numbers in each row of judicative matrix illustrated in table6.

After carrying out the calculations above, the sum of all fuzzy numbers of judicative matrix were obtained and illustrated in table 7 below.

Table 5: Steps of Chang deployment analysis method.

Step	Calculation	Calculation method
1	$\sum_{j=1}^{n} M_{IJ}$	Sum of fuzzy numbers of each rows in judicative matrix
2	$\left[\sum_{I=1}^{M}\sum_{J=1}^{N} M_{IJ}\right]$	Total sum of fuzzy numbers of judicative matrix table
3	S_k value	$S_k = \sum_{j=1}^{n} M_{ij} \otimes \left[\sum_{i=1}^{m}\sum_{j=1}^{n} M_{ij}\right]^{-1}$ M_{ij} is a triangular fuzzy number, *k* indicates the number of row, *i* and *j* indicate row and column respectively.
4	Largeness degree	Generally if M_1 and M_2 are two triangular fuzzy numbers, their degree of largeness in M_1 and M_2 can be defined as below: $\begin{cases} V(M_1 \geq M_2) = 1 & m_1 \geq m_2 \quad if \\ V(M_1 < M_2) = hgt(M_1 \cap M_2) & o.w \end{cases}$ We have: $hgt(M_1 \cap M_2) = \frac{}{(U_1}$ We use the equation below to calculate the degree of largeness for a triangular fuzzy number from *k* other triangular fuzzy numbers $V(M_1 \geq M_2, \ldots, M_k) = V(M_1 \geq M_2).andV(M_1 \geq M_k)$
5	Abnormal weights	Calculating the minimum amount of each column in table obtained in previous step $w'(x_i) = \min\{V(S_i \geq S_k)\} \qquad k = 1, 2, 3, \ldots, n, k \neq i$
6	Obtaining normal vector	We use this equation to obtain normal weights. $W(x_k) = \frac{W'(x_k)}{\sum_{k=1}^{n} W'(x_k)}$

Table 6: The sum of fuzzy numbers in each row of judicative matrix.

Sum of all row i	L	M	U
R_1	10.398	12.697	16.235
R_2	8.372	10.671	13.693
R_3	8.505	10.485	13.685
R_4	8.971	11.423	14.546
R_5	7.945	10.259	13.063
R_6	8.617	11.270	14.526
R_7	8.555	10.994	13.923
R_8	9.077	11.904	15.571
R_9	8.429	10.787	13.716
R_{10}	9.388	12.180	15.769
R_{11}	8.235	10.673	14.259

Table 7: The sum of all fuzzy numbers in judicative matrix.

Total sum of all rows	96.493	123.344	158.986

Then we normalize fuzzy numbers in table 7 and calculate S_k 's weights which are illustrated in table8.

Table 8: S_k 's weights related to each row of judicative matrix.

Si	L	M	U
S_1	0.065	0.103	0.168
S_2	0.053	0.087	0.142
S_3	0.053	0.085	0.142
S_4	0.056	0.093	0.151
S_5	0.050	0.083	0.135
S_6	0.054	0.091	0.151
S_7	0.054	0.089	0.144
S_8	0.057	0.097	0.161
S_9	0.053	0.087	0.142
S_{10}	0.059	0.099	0.163
S_{11}	0.052	0.087	0.148

Then we calculate the degree of largeness for S_j 's regarding S_i 's which are presented in table 9.

Table 9: S_j 's degree of largeness regarding S_i 's.

V(Sj / Si)	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}
S_1	1	0.823	0.810	0.892	0.780	0.880	0.851	0.937	0.832	0.959	0.834
S_2	1	1	0.983	1	0.961	1	1	1	1	1	1
S_3	1	1	1	1	0.978	1	1	1	1	1	1
S_4	1	0.933	0.918	1	0.893	0.987	0.962	1	0.943	1	0.938
S_5	1	1	1	1	1	1	1	1	1	1	1
S_6	1	0.948	0.932	1	0.908	1	0.976	1	0.957	1	0.951
S_7	1	0.971	0.955	1	0.932	1	1	1	0.981	1	0.973
S_8	1	0.895	0.880	0.960	0.854	0.948	0.922	1	0.904	1	0.901
S_9	1	0.990	0.973	1	0.951	1	1	1	1	1	0.990
S_{10}	1	0.871	0.858	0.937	0.831	0.925	0.899	0.979	0.880	1	0.879
S_{11}	1	1	0.983	1	0.961	1	1	1	1	1	1

After that, the minimum number of each column is obtained from table 9 as abnormal weights. Normal weights are calculated by normalizing abnormal weights of table 10.

Table 10: Normal and abnormal weights.

Customer's required features	Wj	Abnormal weights	Normal weights
Technical information	W_1	1	0.1007
Technical services	W_2	0.8233	0.0843
Delicacy of research and deployment	W_3	0.8099	0.0877
Certificate of supplier	W_4	0.8921	0.0957
Financial capacities	W_5	0.7797	0.0812
External environment	W_6	0.8804	0.0918
Amount of discount	W_7	0.8511	0.0902
Organizational culture	W_8	0.9372	0.0884
Company's reputation	W_9	0.8321	0.0873
History of company's operation	W_{10}	0.9591	0.0927
Transportation	W_{11}	0.8339	0.0874

Step seven- determination of technical features in order to select suppliers:

This step is specified to identification of main criteria for evaluation of suppliers. According to case study literature and opinions of experts and professionals presented in statistical sample of the present study, technical indices are indicated in order to select suppliers of pharmaceutic industry in table 11 below.

Table 11: Normal and abnormal weights.

Symbol	Technical features
K_1	expense
K_2	Supplier constancy
K_3	Delivery time
K_4	quality

Step eight- determining the relation of technical features of evaluating supplier according to customers' requirements:

In this stage, we asked each decision maker to state the effect of each technical feature of supplier evaluation on each of customer's required feature using one of five verbal variables as stages below:

Stage1- creating pair comparison matrix between technical features according to "technical information" index like table 12

Table 12: Pair comparison matrix between technical features according to "technical information".

	K_1			K_2			K_3			K_4		
K_1	1	1	1	2	2.5	3	0.5	1	1.5	1	1.5	2
K_2	0.333	0.4	0.5	1	1	1	1.5	2	2.5	2	2.5	3
K_3	0.667	1	2	0.4	0.5	0.667	1	1	1	0.333	0.4	0.5
K_4	0.5	0.667	1	0.333	0.4	0.5	2	2.5	3	1	1	1

Stage2- creating judicative matrix between technical features according to "technical information" index like table 13
Stage3- calculation of sum of rows in judicative matrix like table 14
Stage5- calculation of S_i's weights related to each row of judicative matrix like table 16.
Stage4- calculation of total sum of judicative matrix like table 15

Table 13: Judicative matrix between technical features according to "technical information.

G	K_1			K_2			K_3			K_4		
K_1	1	1	1	1.15	1.7	2.22	0.89	1.43	1.95	1.08	1.47	1.88
K_2	0.45	0.59	0.87	1	1	1	0.53	0.74	1	0.93	1.2	1.53
K_3	0.51	0.7	1.12	1	1.35	1.88	1	1	1	0.43	0.56	0.83
K_4	0.53	0.68	0.92	0.65	0.83	1.07	1.2	1.8	2.34	1	1	1

Table 14: Sum of rows of judicative matrix.

Sum of i^{th} row	L	M	U
R_1	4.124471	5.592776	7.04724
R_2	2.917844	3.530708	3.40113
R_3	1.939558	3.606203	4.832075
R_4	3.387076	4.312327	5.336479

Table 15: Total sum of judicative matrix.

Total sum of rows	12.36895	17.042014	20.616924

Table 16: Calculation of S_i's weights.

Si	L	M	U
S_1	0.200053	0.328176	0.569752
S_2	0.141527	0.207177	0.274973
S_3	0.094076	0.211607	0.390662
S_4	0.164286	0.253041	0.431442

Stage6. Calculation of degree of largeness like table 17

Table 17: Calculation of degree of largeness.

V(Sj/Si)	S_1	S_2	S_3	S_4
S_1	1	0.382404	0.620516	0.754881
S_2	1	1	1	1
S_3	1	0.976097	1	1
S_4	1	0.707034	0.845285	1

Stage7. Calculation of normal and abnormal weights like table 18

Table 18: Normal and abnormal weights.

w_j	Abnormal weights	Normal weights	
W_1	1	0.363	
W_2	0.382404	0.1383	
W_3	0.620516	0.225	
W_4	0.754881	0.274	

Similar to previous stages, the relation between technical features and other necessities required by customers are calculated and summarized in table 19.

Table 19: The relation between technical features and other necessities required by customers.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
K_1	0.363	0.217	0.441	0.256	0.178	0.371	0.244	0.365	0.421	0.146	0.211
K_2	0.138	0.239	0.257	0.4186	0.366	0.227	0.262	0.149	0.188	0.331	0.334
K_3	0.225	0.372	0.149	0.206	0.236	0.152	0.128	0.259	0.158	0.273	0.221
K_4	0.274	0.172	0.152	0.1196	0.219	0.251	0.367	0.226	0.132	0.25	0.223

Stage9- creating quality house matrix:

In this stage, after determining the weight of each need of customers and the relation between technical necessities and each need of customer, the quality house matrix is illustrated as figure2.

Step ten- calculation of relative importance of suppliers:

In this stage we indicate the relative importance of each supplier according to technical features using Fuzzy Analytic Hierarchy Process as below.

Stage eleven- calculation of final importance of suppliers:

After determination of relative weights of suppliers and technical features, the amount of importance of each was calculated as table 21 below.

Stage twelve- after determination of final weights of each supplier, their general and dimensional primacy was indicated as table 22 below.

		The weights of customers' requirements	Technical features K_1	K_2	K_3	K_4
Customer's required features	Technical information	0.1007	0.363	0.138	0.225	0.274
	Technical services	0.0843	0.217	0.239	0.372	0.172
	Delicacy of research and deployment	0.0877	0.441	0.257	0.149	0.152
	Certificate of supplier	0.0957	0.256	0.4186	0.206	0.119
	Financial capacities	0.0812	0.178	0.366	0.236	0.219
	External environment	0.0918	0.371	0.227	0.152	0.251
	Amount of discount	0.0902	0.244	0.262	0.128	0.367
	Organizational culture	0.0884	0.365	0.149	0.259	0.226
	Company's reputation	0.0873	0.421	0.188	0.158	0.132
	History of company's operation	0.0927	0.146	0.331	0.273	0.251
	Transportation	0.0874	0.211	0.334	0.221	0.223
Relative importance of technical features			0.289	0.262	0.213	0.215

Fig. 2: Quality house matrix.

Table 20: Relative weights of suppliers according to technical features.

	expense	constancy	Delivery time	quality
Supplier 1	0.453	0.488	0.146	0.417
Supplier 2	0.188	0.252	0.581	0.126
Supplier 3	0.358	0.261	0.273	0.456

Table 21: Final weights of suppliers.

	expense	constancy	Delivery time	quality	Final weights
	0.289	0.262	0.213	0.215	
Supplier 1	0.453	0.488	0.146	0.417	0.379
Supplier 2	0.188	0.252	0.581	0.126	0.272
Supplier 3	0.358	0.261	0.273	0.456	0.328

Table 22: Ranking suppliers.

	Dimensional primacy				General primacy
	expense	constancy	Delivery time	quality	
Supplier 1	1	1	3	2	1
Supplier 2	3	3	1	3	3
Supplier 3	2	2	2	1	2

Conclusion:

Supply chain management includes integration of activities such as purchase, production programming, logistic, storekeeping, and controlling the stock of warehouse, distribution and delivery. This product presentation process covers services and information which have excess value for customer from the main supplier to the end user. In most organizations, purchase is an important part of supply chain and severely affects the quality and excess value of supply chain and also has a key role in controlling expenses of the chain. In fact the main part of purchase process includes selection of suppliers among others. Evaluation of ranking and accurately selection of organization suppliers not only is an important factor in profitability for organizations, but also is considered as an effective factor in quality of production, service and commercial activities. The notes mentioned, on their part, have deniable effects on life cycle and achievement to subjective of organization in competitive atmosphere today. In the present case study, technical features were identified in order to select suppliers. Then, importance level of each supplier was calculated obtaining the remarks of experts and professional being present in this study and using combined QFD and FAHP approach. The results of data analysis showed that the first supplier with relative priority of 0.379 was the first and the third supplier with relative priority of 0.272 was the third in terms of importance. In the final section of the present research we explain the weak points and shortages of the study and also some suggestions and notes as following. We hope that taking them into practice will guide us to more acceptable and accurate results.

Practical Suggestions:

- Pharmaceutical companies can pay attention to the identified factors in the present study and their weights as far as possible in order to select appropriate supplier.
- Using the designated methodology in the present study is suggested to identify technical features and necessary requirements of customers and selecting an appropriate supplier for other organizations.

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