Performance evaluation of a rig tools supplier by using a fuzzy analytical hierarchy process method

by Misra Hartati

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Abstract: This case study was conducted at a petroleum drilling. In order to fulfil the company's needs, the Department of Supply Chain Management is responsible in the procurements of goods. In this department, there is a procurement division which takes the role of procuring goods towards the suppliers. But all this time, the procurement division is only considering which supplier is going to be used based on the lowest price offer only. But all this time, the procurement division is only considering which supplier is going to be used based on the lowest price offer, and not considering problems caused by suppliers that often lead to the company's loss. This research aims to find out the criteria used in evaluating supplier performance and determining which supplier has the best performance by using fuzzy AHP method. Of the 23 criteria identified, the important criteria that were suitable for evaluating supplier performance were obtained. These criteria are quality, price, delivery, company structure, behaviour, service, and geographic location. In this case study, the chosen supplier is supplier 3. The chosen supplier is supplier 3.

Keywords: fuzzy AHP; performance; supplier; supply chain management.

Reference to this paper should be made as follows: Hartati, M., Kusumanto, I., Gilang, E., Yola, M., Zarnelly, Z. and Heryanti, P. (2022) 'Performance evaluation of a rig tools supplier by using a fuzzy analytical hierarchy process method', *Int. J. Business and Globalisation*, Vol. 30, Nos. 3/4, pp.567–580.

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This paper is a revised and expanded version of a paper entitled 'Performance evaluation of supplier using fuzzy analytical hierarchy process (F-AHP) method' presented at 1st Scientia Academia Conference on Management, Entrepreneurship, and Social Sciences (SAC-MESS 2019), Universiti Teknologi Malaysia, Kula Lumpur, Malaysia, 6–7 April 2019.

1 Introduction

A company which is engaged in the service and manufacturing industry generally aims to get the maximum profit and reduce expenses so the company stays competitive (Panggabean, 2009). Not only getting the maximum profit, but also customer satisfaction becomes the main matter. Therefore, the company is required to be able to provide satisfaction to consumers in all aspects. One of them is maintaining the produced products quality. The first effort in maintaining the product quality is competent supplier selection and able to provide qualified raw materials. Supplier selection needs to be conducted in order to get supplier criteria which can really able to fulfill company needs consistently and with quality (Ngatawi and Setyaningsih, 2011).

Supplier selection is one of the activities in the supply chain. In a supply chain or commonly referred to 'supply chain management', relationship between supplier with the process of procurement cannot be divided. This chain is a network that connects various companies that are interconnected and have the same goal, which is procuring goods (procurement) or distributing (distribution) those goods efficiently and effectively so it will be created a value added towards the product. Choosing and getting supplier that has a good quality and performance are important matters. Four main matters are needed in choosing supplier are quality, quantity, continuity and price. By seeing those matters, choosing the right supplier is a key in procurement process and give a big opportunity for the company to reduce expenses in a procurement process. The right supplier selection method becomes an important problem in order to build effective supply chain system (Arini, 2015 and Lestari et al., 2014).

This case study conduct at petroleum drilling. This company is located in Duri-Dumai Street Km 134 Duri, Riau. Then, this company has nine departments which have their own responsibilities. One of the department in this company is department of supply chain management. This Department is responsible in providing all goods or equipment to support work operations within the company. Internally divided into 3 divisions, which are logistic, procurement (goods procurement), and transportation. Procurement division is fully responsible in fulfilling the procurement of goods for all activities within the company.

In fulfilling company's needs, procurement division utilise the supplier company to fulfil company's needs, such as cafeteria, office stationery, spare part, and rig tools. These four needs are things that must be fulfilled by the procurement division. During this time, in choosing supplier only based on the lowest price offered, but the quality aspect has not been made the main determinant in choosing supplier.

There are 16 suppliers which collaborated with the company. From those suppliers, rig tools supplier is the important matter to be noted. Because rig tools are the main component in petroleum drilling process. So, rig tools supplier is a supplier that is the most influencing matter toward the company. However, what happens to the company is that there are often problems on rig tools supplier. The problem is goods that arrive late and resulting in the loss of the company due to no operation of the rig because the material is there. So it needs to evaluate the rig tools supplier performance.

Delay in goods orders arrival is due to multiple positions of supplier outside of Duri and takes time in distribution. Distance is one of the strongest reasons why goods are often delayed. Long distances can cause delays of up to 2–4 days. Because road conditions are unpredictable.

When the goods are not available in the logistics department, then the procurement has to be as fast as possible to procure the goods. Because these tools are needed in the production process. Procurement will call the supplier. Procurement will ask if the tool is ready and price to each supplier. Later on, the procurement will analyse which price ratio is the lowest, so it will be chosen to place an order. However, quality is not the main indicator in the selection.

From the supplier problems above, it raises loss on the company. The loss is caused by the main company which will not pay the contractor company that does not operate temporarily due to material downtime. If the material is broken, it will be downtime. The length of downtime causes deduction of payment from the main company. Because the principle of the main company is 'no work, no pay'. Phe main company payment to the contractor is IDR 74,000.000/day, which means hourly paid IDR.3,083,333. If it is occurring downtime for two hours due to goods ordered, then the deduction is IDR 6,166,666. This always happens every month.

If this is allowed to continue, it will result in greater losses to the company. Therefore, to solve the loss problem, the decision-making method is used in selecting supplier. In terms of finding and choosing supplier, it must be determined by the people who are interested in making the decision, that is the responsibility of procurement. Then it is used the FAHP method.

2 Research method

To facilitate problem solving in this research, there needed to mind framework which served to facilitate the structured problem solving, so that the solutions obtained were more optimal and functioned as an evaluation tool when finding obstacles in the method used. This mind framework contained the steps or stages carried out during conducting research starting from literature studies, preliminary research, problem identification, problem formulation, research objectives, questionnaire design, data collection, data processing, analysis and conclusions.

The method used in this research was fuzzy analytical hierarchy process (FAHP) method. According to Saaty (1980) AHP was a method used in the decision making process of a complex problem such as planning, determining alternatives, setting priorities, choosing policies, allocating resources, determining needs, predicting needs, planning performance, optimisation, and solving conflicts. Utilising Fuzzy was to accommodate the cryptic nature (uncertainty) happened during the decision-making. The pairwise comparison matrix from AHP method was changed into pairwise comparison matrix fuzzy where linguistic changes in decision makers inteIDRreted into triangular fuzzy number (TFN). By changing the preferences of decision makers into TFN, the weighting will be simpler (Noviandri et al., 2015).

The problem which was going to be solved using the fuzzy AHP method was to find out the priority level used in evaluating supplier performance. The criteria used were quality, delivery, price, company structure, service, behaviour, and geographic location. Next, it is continued by ranking supplier performance from the best to the worst.

3 Result and discussion

3.1 *Criteria and sub-criteria determination in supplier performance evaluation through questionnaire 1 and 2*

On questionnaire 1 (first), the four respondents are asked to provide an assessment of the level of importance of the main criteria first, if the criteria are considered important then the assessment is continued by conducting a subsequent assessment of the importance level of the sub-criteria.

From the calculation, the criteria have value of =>4 is the criteria of quality, price, delivery, service, company structure, flexibility, and K3. These seven criteria will be used in further distribution of the questionnaire. Each criterion will have its respective sub-criteria obtained from some literature, which are the research from Handayani (2009).

3.2 *Processing with fuzzy analytical process (F-AHP)*

After the criteria and sub-criteria have been obtained to evaluate the supplier's performance obtained, then process the data using the F-AHP method.

3.2.1 Fuzzy performance matrix calculation

The puIDRose of making fuzzy matrix is to give weight to alternative assessments that have been obtained in the calculation of the fuzzy assessment matrix.

- Creating fuzzy weight vectors

Data used in making fuzzy weight vector is a pairwise comparison of the criteria given by the expert. There are experts who have assess the pairwise comparison.

After obtaining the weight of each criterion, then it needs to compel these values, make it into fuzzy number and then make a combined pairwise comparison matrix. The formulation is in the following:

Example: Criterion of quality (K1) towards delivery (K2)

$$L_{12} = \min\ (3,1,1,5) = 1$$

$$M_{12} = \frac{(3+1+1+5)}{4} = 2,5$$

$$U_{12} = \max\ (3,1,1,5) = 5$$

Then, the fuzzy combined pairwise comparison is:

$$\tilde{b}_{12} = (1, 2,5, 5)$$

And so on. After the calculations for all the criteria are completed, then a fuzzy combined pairwise comparison is recapitulated.

After obtaining the values in the fuzzy combined pairwise comparison matrix, the next step is to calculate the weight of each criterion.

$\tilde{w}_j$: relative weight towards performance *j*.

The following is the calculation:

$$\tilde{w}_1 = \frac{(1, 1, 1) \oplus (1, 2.5, 5) \oplus (1, 2, 3) \oplus \ldots\ldots\ldots.(5, 6.6, 9)}{(81.626, 123.54, 166.161)}$$

$$= (0.170, 0.304, .0551)$$

$$\tilde{w}_2 = \frac{(0.333, 0.633, 1) \oplus (1, 1, 1) \oplus (0.111, 0.196, 0.2) \oplus \ldots\ldots\ldots.(1, 5, 7)}{(81.626, 123.54, 166.161)}$$

$$= (0.092, 0.196, 0.260)$$

$$\tilde{w}_3 = \frac{(0.333, 0.666, 1) \oplus (3, 6, 9) \oplus (1, 1, 1) \oplus \ldots\ldots\ldots.(5, 6.5, 7)}{(81.626, 123.54, 166.161)}$$

$$= (0.138, 0.255, 0.502)$$

$$\tilde{w}_4 = \frac{(0.2, 0.266, 0.333) \oplus (0.2, 0.266, 0.333) \oplus (0.111, 0.149, 0.2) \oplus \ldots\ldots\ldots.(3, 5, 7)}{(81.626, 123.54, 166.161)}$$

$$= (0.051, 0.110, 0.231)$$

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$$\tilde{w}_5 = \frac{(0.111, 0.141, 0.2) \oplus (0.111, 0.163, 0.2) \oplus ....(0.333, 2.333, 3)}{(81.626, 123.54, 166.161)}$$

$$= (0.007, 0.072, 0.121)$$

$$\tilde{w}_6 = \frac{(0.111, 0.135, 0.143) \oplus (0.111, 0.163, 0.2) \oplus ....(0.333, 2.333, 5)}{(81.626, 123.54, 166.161)}$$

$$= (0.012, 0.049, 0.128)$$

$$\tilde{w}_7 = \frac{(0.111, 0.163, 0.2) \oplus (0.143, 0.371, 1) \oplus (0.143, 0.157, 0.2) \oplus ....(1, 1, 1)}{(81.626, 123.54, 166.161)}$$

$$= (0.012, 0.032, 0.106)$$

The weights calculation of the other three criteria can be calculated in similar way, the result of the calculation is the fuzzy weight vector as follows:

$$W = (\tilde{w}_1, \tilde{w}_2, \tilde{w}_3, \tilde{w}_4, \tilde{w}_5, \tilde{w}_6, \tilde{w}_7)$$

$$= \begin{Bmatrix} (0.138, 0.255, 0.502), (0.092, 0.196, 0.260), (0.170, 0.304, 0.551), \\ (0.051, 0.110, 0.231), (0.007, 0.072, 0.121), (0.012, 0.049, 0.128), \\ (0.012, 0.032, 0.106) \end{Bmatrix}$$

The following table is the recapitulation of the weight of each supplier evaluation criteria.

Table 1 Recapitulation of supplier assessment criteria weight

Criteria	*Weight*
Quality (K1)	0.551
Delivery (K2)	0.260
Price (K3)	0.502
Company structure (K4)	0.231
Service (K5)	0.121
Behaviour (K6)	0.128
Geographic location (K7)	0.106

From the weight vector above, it gets the order of criteria importance used in supplier performance evaluation. The order is quality, price, delivery, company structure, behaviour, service, and geographic location.

3.2.2 Fuzzy matrix calculation

After the answer from the respondent is recapitulated, a calculation will be made for each criterion for the alternative. Other alternative calculations can be conducted in similar way. After obtaining a combination of alternative assessments, these values are normalised. The results of this operation are called fuzzy assessment matrix of sub-criteria towards criteria.

3.2.3 Crisp performance matrix calculation

This section will discuss the value statement of confidence of the decision maker and the risks posed related to the problem of determining the supplier performance priority level in this study.

3.2.3.1 α-cut value calculation

Value α indicates or symbolises the level of confidence of the decision maker towards the subjective evaluation conducted in relation to alternative assessments and criteria weighting. The greater the α value symbolises the higher the sense of confidence of the decision maker and will be closer to most likely value (middle value) of triangular fuzzy numbers.

In this study, the sense of confidence in the opinions given is quite high. Therefore, it is decided that the α value to be used is 0.85. The interval performance matrix calculation is the first step of defuzzification given. The following is an alternative calculation for each criterion. The description of the symbol below is:

$\tilde{h}ij$ fuzzy performance matrix score from alternative i is relative towards criterion j by triangular fuzzy numbers. The calculation is in the following:

Price (K1)

A_1

$$h_l^{0.85} = 0.004002 + 0.85\ (0.07114 - 0.004002) = 0.0611$$

$$h_l^{0.85} = 0.254514 - 0.850(0.254514\ 0.07114) = 0.0986 = 0.0207$$

And so on.

3.2.3.2 Risk index calculation

The decision maker gives the conclusion that the risk value used is 0.5, which means in this case the assessment given is not too optimistic and not too pessimistic.

Calculation example:

Quality (K1)

$$\text{A1}: h_{11,0.5}^{0.85} = 0.5 \times 0.0611 + 0.85 \times 0.0986 = 0.1144$$

Delivery (K2)

$$\text{A1}: h_{11,0.5}^{0.85} = 0.5 \times 0384 + 0.85 \times 0.0569 = 0.0676$$

Price (K3)

$$\text{A1}: h_{11,0.5}^{0.85} = 0.5 \times 0.0854 + 0.85 \times 0.1235 = 0.0147$$

Company structure (K4)

$$\text{A1}: h_{11,0.5}^{0.85} = 0.5 \times 0.0141 + 0.85 \times 0.0275 = 0.0304$$

Service (K5)

$$\text{A1}: h_{11,0.5}^{0.85} = 0.5 \times 0.0034 + 0.85 \times 0.0085 = 0.0089$$

Behaviour (K6)

$A1{:}h^{0.85}_{11,0.5} = 0.5 \times 0.0070 + 0.85 \times 0.0145 = 0.0158$

Geographic Location (K7)

$A1{:}h^{0.85}_{11,0.5} = 0.5 \times 0.0036 + 0.85 \times 0.0098 = 0.0101$

3.2.4 Sub-criterion ranking

Presently, it has a crisp or certain value from each alternative to each criterion. Furthermore, it can be seen here that there are several alternatives which have advantages in one criterion but are low in value in another. Therefore, it needs a method that can balance the crisp value and produce the final ranking. By determining the value of ideal solutions and negative ideal solutions for each criterion. The value of a positive ideal solution and a negative ideal solution are as follows:

$$h^{0.85+}_{K1,05} = 0.1324,\ h^{0.85+}_{K2,0.5} = 0.0676,\ h^{0.85+}_{K3,0.5} = 0.1477,\ h^{0.85+}_{K4,0.5} = 0.0554,$$
$$h^{0.85+}_{K1,0.5} = 0.0354,\ h^{0.85+}_{K2,0.5} = 0.0272,\ h^{0.85+}_{K3,0.5} = 0.0192$$

$$h^{0.85-}_{K1,0.5} = 0.0219,\ h^{0.85-}_{K2,0.5} = 0.0219,\ h^{0.85-}_{K3,0.5} = 0.0392,\ h^{0.85-}_{K4,0.5} = 0.0154,$$
$$h^{0.85-}_{K1,0.5} = 0.0089,\ h^{0.85-}_{K2,0.5} = 0.0049,\ h^{0.85-}_{K3,0.5} = 0.0037$$

Desc:

$h^{\alpha}_{ij\beta}$ crisp performance score of each alternative i relative towards criterion j with the level of confidence α and risk index β

$S^{\alpha+}_{j\beta}$ and $S^{\alpha-}_{j\beta}$ range between $h^{\alpha}_{ij\beta}$ from alternative i relative towards all criterion and all ideal solutions as well as negative ideal solutions

After obtaining the value of a ideal solution and a negative ideal solution for each criterion, then calculate the distance between the ideal solution and the negative ideal solution for each alternative, the calculation for each alternative below is:

a Sub-criteria 1

$$S^{0.85+}_{K1,0.5} = \sqrt{\sum_{j=1}^{7} \left(h^{0.85}_{1j,0.5} - h^{0.85+}_{j,0.5}\right)^2}$$

$$\sqrt{\sum_{j=1}^{7} \begin{Bmatrix} (0.1144 - 0.1324)^2 + (0.0676 - 0.0676)^2 \\ (0.1477 - 0.1477)^2 + (0.0101 - 0.0192)^2 \end{Bmatrix}}$$

$$= 0.0432$$

$$S^{0.85-}_{K1,0.5} \sqrt{\sum_{j=1}^{7} \left(h^{0.85}_{1j,0.5} - h^{0.85-}_{j,0.5}\right)^2}$$

$$\sqrt{\sum_{j=1}^{7}\begin{Bmatrix}(0.1144-0.0219)^2+(0.0676-0.0219)^2\\(0.1477-0.0392)^2-(0.0101-0.0037)^2\end{Bmatrix}}$$

$$=\ 0.1510$$

b Sub-criteria 2

$$S_{K1,0.5}^{0.85+}=\sqrt{\sum_{j=1}^{7}\left(h_{1j,0.5}^{0.85}-h_{j,0.5}^{0.85+}\right)^2}$$

$$\sqrt{\sum_{j=1}^{7}\begin{Bmatrix}(0.1039-0.1324)^2+(0.0465-0.0676)^2\\(0.0535-0.1477)^2\ .....+(0.0171-0.0192)^2\end{Bmatrix}}$$

$$=\ 0.1018$$

$$S_{K1,0.5}^{0.85-}\sqrt{\sum_{j=1}^{7}\begin{Bmatrix}(0.1039-0.0219)^2+(0.0465-0.0219)^2\\(0.0535-0.0392)^2\ .....+(0.0171-0.0037)^2\end{Bmatrix}}$$

$$\sqrt{\sum_{j=1}^{7}\begin{Bmatrix}(0.1039-0.0219)^2+(0.0465-0.0219)^2\\(0.0535-0.0392)^2\ .....+(0.0171-0.0037)^2\end{Bmatrix}}$$

$$=0.0957$$

And so on.

Table 2 Recapitulation of the distance between positive ideal solution and negative ideal solution with the alternative

Subcriteria	*Distance*	
	Ideal solution ($S_{K1,0.5}^{0.85+}$)	*Negative solution* ($S_{K1,0.5}^{0.85-}$)
A1	0.0432	0.1510
A2	0.1018	0.0957
A3	0.1018	0.1076
A4	0.0429	0.1549
A5	0.1056	0.0789
A6	0.0891	0.1037
A7	0.0693	0.1106
A8	0.0724	0.1082
A9	0.0621	0.1170
A10	0.0627	0.1359
A11	0.0520	0.1466
A12	0.0535	0.1463
A13	0.1258	0.0843
A14	0.1455	0.0654
A15	0.1220	0.0552

Table 2 Recapitulation of the distance between positive ideal solution and negative ideal solution with the alternative (continued)

Subcriteria	*Distance*	
	Ideal solution($S_{K1,0.5}^{0.85+}$)	*Negative solution* ($S_{K1,0.5}^{0.85-}$)
A16	0.0591	0.1280
A17	0.0572	0.1302
A18	0.0607	0.1246
A19	0.1091	0.0668
A20	0.1500	0.0454
A21	0.1271	0.0687

Table 3 Final performance value

Subcriteria	*Name of subcriteria*	*Total performance values*
A1	Subcriteria 1	0.7775
A2	Subcriteria 2	0.4846
A3	Subcriteria 3	0.6052
A4	Subcriteria 4	0.7831
A5	subcriteria 5	0.4276
A6	Subcriteria 6	0.5379
A7	Subcriteria 7	0.6148
A8	Subcriteria 8	0.5991
A9	Subcriteria 9	0.6533
A10	Subcriteria 10	0.6843
A11	Subcriteria 11	0.7382
A12	Subcriteria 12	0.7322
A13	Subcriteria 13	0.4012
A14	Subcriteria 14	0.3101
A15	Subcriteria 15	0.3115
A16	Subcriteria 16	0.6841
A17	Subcriteria 17	0.6948
A18	Subcriteria 18	0.6724
A19	Subcriteria 19	0.3798
A20	Subcriteria 20	0.2323
A21	Subcriteria 21	0.3509

Final performance assessment is the final value obtained where the value represents the relative closeness to the ideal solution, the final performance value is α = 0.85 and β = 0.5, for each alternative, the final performance value is in the following:

Desc $R_{ij\beta}^{\alpha}$: final performance score, where contained confidence level α and risk index β for alternative *i*.

Example: Sub-criterion 1

$$R_{1,0.5}^{0.85} = \frac{S_{1,0.5}^{0.85-}}{S_{1,0.5}^{0.85+} + S_{1,0.5}^{0.85-}} = \frac{0.1510}{0.0432 + 0.1510} = 0.7775$$

The values are then sorted from the largest to the smallest to indicate which alternatives will be prioritised.

3.2.5 *Ordering priority of the best supplier*

After obtaining weights from the criteria used in supplier assessment, the next is knowing which of the four rig suppliers has the best performance based on the seven criteria.

The steps used in sorting supplier performance are calculating geometric mean values because in the initial calculation only needs one average answer that represents the respondent's answer. Here is the supplier name in this case study involving supplier 1, supplier 2, supplier 3 and supplier 4.

Table 4 Supplier weighting results based on quality

Supplier	*S1*	*S2*	*S 3*	*S4*
S1	1	0.258	0.577	0.439
S2	3.873	1	0.439	5.916
S3	1.732	2.279	1	3.873
S4	2.279	0.169	0.258	1

Table 5 Supplier weighting results based on delivery

Supplier	*S1*	*S2*	*S3*	*S4*
S1	1	0.169	0.169	0.439
S2	5.916	1	0.293	2.279
S3	5.916	3.409	1	5.917
S4	2.279	0.439	0.169	1

Table 6 Supplier weighting results based on price

Supplier	*S1*	*S2*	*S3*	*S4*
S1	1	0.137	0.134	2.943
S2	7.297	1	0.577	7.937
S3	7.454	1.732	1	8.452
S4	0.440	0.126	0.118	1

Table 7 Supplier weighting results based on company structure

Supplier	*S1*	*S2*	*S3*	*S4*
S1	1	0.508	0.258	3.409
S2	1.968	1	0.577	5.917
S3	3.873	1.732	1	5.917
S4	0.293	0.169	0.169	1

Table 8 Supplier weighting results based on service

Supplier	*S1*	*S2*	*S3*	*S4*
S1	1	0.259	0.258	5.439
S2	3.873	1	0.293	5.917
S3	3.873	3.409	1	6.435
S4	0.184	0.169	0.155	1

Table 9 Supplier weighting result based on behaviour

Supplier	*S1*	*S2*	*S3*	*S4*
S1	1	0.508	0.184	4.401
S2	1.968	1	0.577	3.873
S3	5.439	1.732	1	4.787
S4	0.227	0.258	0.209	1

Table 10 Supplier weighting results based on geographic location

Supplier	*S1*	*S2*	*S3*	*S4*
S1	1	0.227	0.227	6.299
S2	4.400	1	0.439	6.853
S3	4.400	2.279	1	7.937
S4	0.159	0.146	0.126	1

After obtaining weighting from each criterion, then we need to compel these values, make them into fuzzy numbers and then make a combined pairwise comparison matrix. The calculation example is as follows:

a Supplier 1 (S1) towards supplier 2 (S2)

$$L_{12} = \min\ (0.258,\ 0.169,\ 0.137,\ 0.508,\ 0.259,\ 0.508,\ 0.227) = 0.137$$

$$M_{12} = \frac{(0.258 + 0.169 + 0.137 + 0.508 + 0.259 + 0.508 + 0.227)}{7}$$

$$= 0.295$$

$$U_{12} \max = (0.258,\ 0.169, 0.137,\ 0.508,\ 0.259,\ 0.508,\ 0.227) = 0.508$$

Then, the fuzzy pairwise comparison value is:

$$\tilde{b}_{12} = (0.137, 0.295, 0.508)$$

After the fuzzy combined pairwise comparison value is obtained, then next is calculating weight of each supplier.

$$\tilde{w}_1 = \frac{(1, 1, 1) \oplus (0.137, 0.295, 0.508) \oplus (0.134, 0.258, 0.577) \oplus (0.439, 3.338, 6.299)}{(16.998, 32.503, 47.924)}$$

$$= (0.035, 0.150, 0.493)$$

$$\tilde{w}_2 = \frac{(1.968, 4.185, 5.916) \oplus (1, 1, 1) \oplus (0.293, 0.456, 0.577) \oplus (2.279, 5.527, 7.937)}{(16.998, 32.503, 47.924)}$$
$$= (0.115, 0.343, 0.907)$$

$$\tilde{w}_3 = \frac{(1.732, 4.669, 7.454) \oplus (1.732, 2.367, 3.409) \oplus (1, 1, 1) \oplus (3.873, 6.188, 8.452)}{(16.998, 32.503, 47.924)}$$
$$= (0.173, 0.376, 1.195)$$

$$\tilde{w}_4 = \frac{(0.159, 0.837, 2.279) \oplus (0.126, 0.211, 0.258) \oplus (0.126, 0.172, 0.258) \oplus (1, 1, 1)}{(16.998, 32.503, 47.924)}$$
$$= (0.029, 0.068, 0.223)$$

The weights calculation of the other three criteria can be calculated in the same way, the result of the calculation is the fuzzy weight vector below:

$$\text{W} = (\tilde{w}_1, \tilde{w}_2, \tilde{w}_3, \tilde{w}_4,)$$
$$= \{(0.035, 0.150, 0.493), (0.115, 0.343, 0.907), (0.173, 0.376, 0.1.195)$$
$$(0.029, 0.068, 0.223)\}$$

After obtaining the supplier weight ranking, then it is sorted from which has the largest to the smallest weight. So the following result is:

Table 11 Supplier assessment ranking

Supplier	*Weight*
Supplier 3	1.195
Supplier 2	0.907
Supplier 1	0.493
Supplier 4	0.223

4 Conclusions

The conclusion of this research is that it obtained the order of criteria and sub-criteria such as quality with the weight of 0.551, price with the weight of 0.502, delivery with the weight of 0.260, company structure with the weight of 0.231, behaviour with the weight of 0.128, service with the weight of 0.121, and geographic location with the weight of 0.106. And the supplier who has the best performance is supplier 3 with the weight of 1,195, next is supplier 2 with the weight of 0.907, supplier 1 with the weight of 0.493, and supplier 4 with the weight of 0.223.

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