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An Application Of Analytic Hierarchy Process And Fuzzy Analytic Hierarchy Process to the Case Type Selection Problem

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Abstract

Business enterprises need to show high performance in their industries in order to achieve a sustainable competition. This is not related only to individual performances, and each link on supply chain may have a considerable effect on business performance. Therefore, supply chain management is quite essential to the enterprises that supplier selection is one of its key elements to be run, and another is establishing the form of packaging before the supplier delivers the ordered raw materials. Raw material costs are influenced by the ability to determine such issues as packaging way, type of case, etc., and these factors are also important to maintain the quality of material. The aim of this study is to select the type of the case for raw materials to be placed in by the supplier, in the automobile industry with very intense competition. In order to solve this multi-criteria decision making problem, the Analytic Hierarchy Process (AHP), one of the multi-criteria decision making techniques, was used. Due to the ambiguity in several paired comparisons, the problem was also resolved using the Fuzzy Analytic Hierarchy Process (Fuzzy AHP).
Key words: Multi Criteria Decision Making, Analytic Hierarchy Process, Fuzzy Analytic Hierarchy Process

1. Introduction

The fierce competition in business leads to shorter product life-cycles and increasingly higher customer expectations. The companies that can be survived in the competitive environment are just the ones who can organize and manage their supply chains efficiently. The greater their responsiveness to customers and the client satisfaction are, the higher their operational performances for supply chain are. The efficient option for supplier is one of the key indicators to promote supply chain management performance, which involves identifying the number of suppliers and the supplier evaluation criteria. In literature, the number of contributing factors have been reported in several supply selection studies. Thus, there are so many examples that multi-criteria decision-making methods have been used. These techniques gather and enable many factors, measurable or non-measurable, to be co-evaluated. AHP (Analytic Hierarchy Process), Electre (Elimination and Choice Translating Reality), Topsis (Technique for Order Preference by Similarity to Ideal Solution), Promethee, Vikor, etc are very popular to use in applications.

There are a great number of studies conducted on supplier selection that is essential for business companies. Kumar et al. (2018) studied a model in which Taguchi loss function, AHP and TOPSIS methods were integrated in order to find the most suitable supplier to an Indian Heavy Locomotive Company. In fact, Abd el-Basset et al. (2018) highlighted in a study in which AHP and QFD were integrated within a neuro-phasic environment that the best option for supplier selection is necessary to promote service delivery in quality and quantity, reduce costs, and control time. Furthermore, Azimifard et al. (2018) first identified the sustainability criteria using AHP (CO2 emissions, the number of employees in the suppliers' country industry, water

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consumption and distance from supplier's country) and then performed the supplier selection for Iran Steel Industry through the Topsis method. Awasthi et al. (2018) examined a global sustainable supplier selection as a main topic. In their analyses, these authors used Fuzzy-AHP to find the weights for criteria and Fuzzy-Vikor method to evaluate the suppliers according to these factors. In a trial, Sirisawat and Kiatcharoenpol (2018) conducted the reverse logistic application in Thailand Electronics industry and applied Fuzzy-AHP and Fuzzy-Topsis methods to identify the related problems and list the solution recommendations. In another study regarding supply chain problems, Patil and Kant (2014) offered a Fuzzy-AHP – Topsis-based solution to describe and prioritize information management solutions in order to overcome the handicaps in supply chain. Dağdeviren and Eren (2001) studied on how AHP and target programming techniques have effect on the supplier selection, under the four pre-specified criteria, and reported what considerations should be taken when using the methods. Soner and Önüt (2006) also used two multi-criteria decision making methods: one is the AHP to establish the weights of the criteria and the other is the Electre to evaluate them.

A standard supply chain involves appropriate ways of supplying raw materials necessary to produce in plants, storing the final products and delivering to the retailers or customers. Supply chain consists of several components including manufacturing sites, storages, distribution centers, and retail shops as well as suppliers. Each one has part in the chain. Both accuracy in supply selection and proper delivery of packaged materials without any defects are equally important. Although this issue seems to be under responsibility of the supplier party, if the materials are damaged during transportation, the main company will be influenced from this problem, and hence it is also crucial for the manufacturer.

In this study, we examine the problem of appropriate case selection for an auto company in trouble about the packaging of raw materials made by the supplier. This has been solved using AHP, a multi-criteria decision-making method because there are eight different case types to send to the suppliers so that they will use them in packing their ordered raw materials, and five different criteria to use in case selection. In the second part of our study, the results of literature review are presented including the implementation phases of AHP and Fuzzy-AHP. And then in the third part, we explain the project implementation in automobile company and in the discussion part, mention about the comparison of the results of both methods used to solve.

2. Materials and Method

2.1. Analytic Hierarchy Process

AHP is a multi-criteria decision making method developed by Saaty in 1970s (Saaty, 1987). In this method, the objectives of the problem and the main and sub-criteria are alternately established in order, paired comparisons are made between the criteria and the alternatives to identify the weights, and finally the alternatives are ranked in order of importance.

AHP is one of the multi-criteria decision-making methods in which multiple decision makers are involved in making decisions in a decision environment with multiple alternatives. The criteria to be used for the selection process may be quantitative or qualitative. The AHP method first divides the problem into small pieces, then pairwise-compares, priorities for each hierarchy, and thus regulates a certain logical process (Yıldız and Aksoy, 2015). Follow these steps for the AHP solution: (1) definition of decision making problem, determination of purpose, list of decision criteria and alternatives, (2) making pairwise comparisons (the scale of significance used in paired comparisons is given in table 1), pairwise comparison of alternatives according to criteria and determination of priorities, (3) sorting of alternatives according to relative priority values (The generated comparison matrix is normalized. For this, column totals are taken and each value is divided by its own column sum. Thus, normalized matrix is obtained. After the normalized operation, the priority or weight vectors for the items compared in the hierarchy are calculated), selecting the highest value alternative as the solution of the problem, (4) sensitivity analysis (Yıldırım and Önder (2015), Gür et al. (2017)).

Table 1: Scores for the importance of variable

Importance Scale	Definition of Importance Scale
1	Equally Important Preferred
2	Equally to Moderately Important Preferred
3	Moderately Important Preferred
4	Moderately to Strongly Important Preferred
5	Strongly Important Preferred
6	Strongly to Very Strongly Important Preferred
7	Very Strongly Important Preferred
8	Very Strongly to Extremely Important Preferred
9	Extremely Important Preferred

2.2. Fuzzy Analytic Hierarchy Process

Although the use of scales numbered 1 to 9 in the AHP method is simple to use, there are a number of inconsistencies. In addition, decision makers generally find intermittent decision making more comfortable than making a fixed-value decision. Therefore, this method is insufficient to explain the uncertainty and the number of decision makers. Therefore, Fuzzy AHP was developed to reflect human thinking. Traditional Fuzzy AHP methods deal with fuzzy values in operations using exhaustive arithmetic calculations. Furthermore, another disadvantage of these methods is the need for extra rinse to achieve a precise result. In Chang's approach, the above-mentioned disadvantages are not valid, since calculations are made by the intersection of fuzzy numbers (Çanlı and Kandakoğlu, 2007). For this reason, this study was based on Chang‘s approach. The stages of the method (Aydın (2009), Şimşek et al. (2014), Kaptanoğlu and Özok (2006));

Stage 0: X={$x_1, x_2, \ldots, x_n$}is the criterion set and U={$u_1, u_2, \ldots, u_n$}is the target set, For each target, the degree analysis (gi) is applied considering each criterion. M degree analysis value for targets, i = 1,2,…, n and j = 1,2, …, m; $M_{gi}^1, M_{gi}^2, \ldots, M_{gi}^n$ is expressed in the form of triangular fuzzy numbers.

Stage 1: The fuzzy synthetic grade value for the i criterion is defined as;

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1} \quad (1)$$

Here are the following equations (l_i, m_i, u_i) to be a triangular fuzzy number;

$$\sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j, \right) \quad (2)$$

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1} = \left(\frac{1}{\sum_{j=1}^{n} u_j}, \frac{1}{\sum_{j=1}^{n} m_j}, \frac{1}{\sum_{j=1}^{n} l_j} \right) \quad (3)$$

Stage 2: The weight vector indicated by W = ((d (A_1), d (A_2),… d (A_n))^T is calculated. The vector W is obtained by normalizing the W′ weight vector. i = 1,2,…, n, the following calculations are made;

$$W' = ((d'(A_1), d'(A_2), \ldots d'(A_n))^T \quad (4)$$

$$d'(A_i) = \min V(S_i \geq S_k),\ k=1,2,\ldots,n \text{ ve } k \neq i \quad (5)$$

For the triangular fuzzy numbers $M_1 = (l_1, m_1, u_1)$ and M2 = (l_2, m_2, u_2); the values of V ($M_1 \geq M_2$) and V ($M_2 \geq M_1$) are calculated and M_1 and M_2 numbers are compared. To do this, V ($M_2 \geq M_1$) is defined as the following format to indicate the possibility of $M_2 \geq M_1$.

$$V(M_2 \geq M_1) = \begin{cases} 1 & , m_2 \geq m_1 \\ 0 & , l_1 \geq u_2 \\ \dfrac{(l_1 - u_2)}{(m_2 - u_2) - (m_1 - l_1)} & , \text{dd} \end{cases} \quad (6)$$

Using the equation (6), d′(A_i) values are calculated according to (5). From here, the vector W′ and the vector W are calculated. The final decision is made in accordance with the hierarchical structure of the classical AHP approach with the non-fuzzy W weight vector calculated based on the comparison matrix obtained by triangular fuzzy numbers.

3. Results

The main issue of the department of logistics or procurement in an auto company is the purchased materials put into the cases being delivered from the suppliers, with the appropriate cases to be arranged for the materials. Since there were so many purchases for the automobile company, radiator, one of critical parts also for the company, will be examined in this study. There are eight case alternatives for its inputs to place in, five in plastic and three in metal (POA, POC, POD, POG, POE, 002, 00B, 00D). The suppliers have to follow several packing criteria before the delivery, as follows: * Weight of materials (max. 12 kg in the cases to manually lift in accordance with job occupational health and safety standards). * Volume of materials (in certain limits for each case; bigger materials cannot be put into smaller cases). * Amount of use (the big cases containing the materials which are used much less in quantity per day contribute to the increased cycle times, resulting in unnecessary loss of spaces in their locations near the production lines, which is an undesired situation). * Requests of quality control department in the automotive company (type of cases that has been identified depending on the material vulnerability may not be accepted by the quality department). * Supplier’s choice (suppliers may prefer the cases to fit to their own hardware)

Each case weighs 410 g, with the volume of 1414 cm3. Daily demand is 15 units of materials (radiators in our case). The number of cases need to be delivered to the supplier for the radiator parts, otherwise they can put them into cardboard boxes, which may influence the quality of material.

3.1. AHP Application

In the light of the above-mentioned criteria, the hierarchical structure for AHP model established to solve the packaging problem of the company is illustrated in Figure 1.

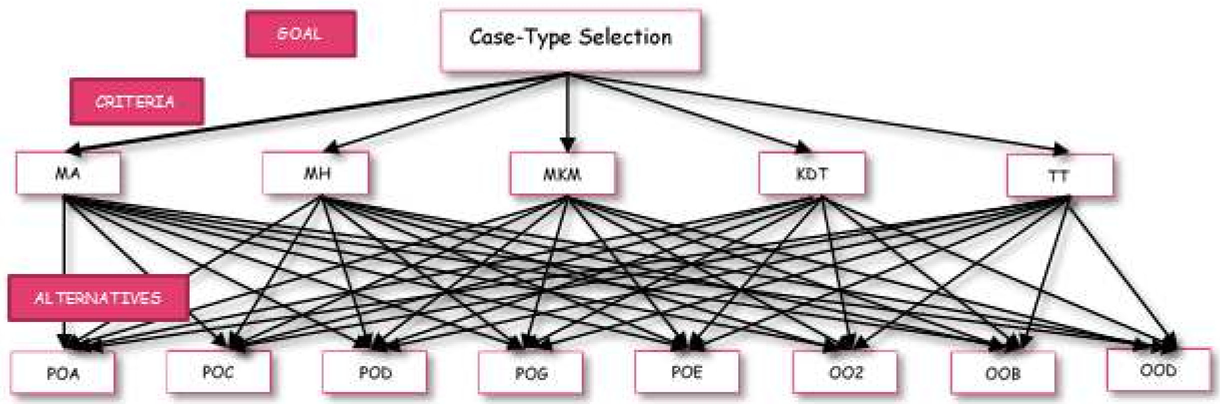

Figure 1: AHP Hierarchical Structure

The structure that illustrated in figure 1 is based on five criteria (including weight (MA), volume (MH), amount of use of materials (MKM), requests from quality department (KDT), and supplier's choice (TT)) and eight alternatives (POA, POC, POD, POG, POE, 002, 00B, 00D).

Establishment of Criteria Weights

Following the hierarchical structure, the relative weights of importance between equal criteria in priority should be established. Therefore, the matrices of pairwise comparisons have been developed together with the company's procurement specialists. The pairwise comparisons between the criteria are demonstrated in Table 2.

Table 2: Pairwise comparison of criterion

	MA	MH	MKM	KDT	TT
MA	1	1/3	7	3	5
MH	3	1	9	5	7
MKM	1/7	1/9	1	1/9	1/5
KDT	1/3	1/5	9	1	8
TT	1/5	1/7	5	1/8	1

Table 2 presents the comparisons of criteria designed together with procurement staff. For example, the criterion of "weight of material" has higher significance than that of "volume of material". Normalization is made for the procedure of synthesis in AHP. For this, each column in Table 2 is summed up, and each value in matrix is divided by the total of its column. The normalized values of paired comparisons are displayed in Table 3. The last column in Table 3 shows the weighted average representing the relative importance for each criterion, calculated by dividing the total of row by five.

Table 3: Normalized values and weighted average of the criteria

	MA	MH	MKM	KDT	TT	WEIGHTED AVERAGE
MA	0.214	0.187	0.226	0.325	0.236	0.237
MH	0.642	0.560	0.290	0.541	0.330	0.473
MKM	0.031	0.062	0.032	0.012	0.009	0.029
KDT	0.071	0.112	0.290	0.108	0.377	0.192
TT	0.043	0.080	0.161	0.014	0.047	0.069
TOTAL	1.00	1.00	1.00	1.00	1.00	1

As seen in Table 3, the ideal out of five criteria is the volume of material at 0.472 to achieve the "appropriate selection for each material" while others are sorted from largest to smallest weighted average.

Establishment of Weights for the Alternatives

The next step in AHP is to make paired comparisons between the alternatives for each criterion and define their order of priority. Here, the priorities for the alternatives are simply identified based on the "weight of material", and likewise the prioritization is also done according to the other criteria. Table 4 displays the normalized values and the weighted averages of the paired comparisons of the alternatives based on "weight of material".

Table 4: Normalized values and weighted average of alternatives according to "material weight" criterion

	POA	POC	POD	POG	POE	002	00B	00D	WEIGHTED AVERAGE
POA	0.021	0.012	0.007	0.007	0.042	0.025	0.017	0.013	0.018
POC	0.042	0.025	0.008	0.008	0.048	0.028	0.020	0.015	0.024
POD	0.104	0.099	0.033	0.010	0.054	0.037	0.023	0.019	0.047
POG	0.146	0.148	0.164	0.049	0.063	0.045	0.035	0.023	0.084
POE	0.188	0.198	0.230	0.293	0.381	0.451	0.418	0.372	0.316
002	0.188	0.198	0.197	0.244	0.190	0.225	0.278	0.279	0.225
00B	0.167	0.173	0.197	0.195	0.127	0.113	0.139	0.186	0.162
00D	0.146	0.148	0.164	0.195	0.095	0.075	0.070	0.093	0.123
TOTAL	1	1	1	1	1	1	1	1	1

According to these results, POE is the best alternative because of its highest weighted average. Furthermore, the establishment of relative importance levels for all the alternatives using the other criteria has been completed (see Table 5).

Table 5: Relative importance of alternatives

	MA	MH	MKM	KDT	TT	Total Weight
POA	0.018	0.020	0.018	0.020	0.547	0.056
POC	0.024	0.027	0.025	0.026	0.543	0.062
POD	0.047	0.053	0.087	0.048	0.554	0.086
POG	0.084	0.044	0.052	0.060	0.560	0.093
POE	0.316	0.273	0.309	0.294	0.608	0.312
002	0.225	0.341	0.370	0.478	0.093	**0.324**
00B	0.162	0.108	0.117	0.096	0.062	0.116
00D	0.123	0.169	0.198	0.176	0.041	0.152

The alternatives' total weights or total relative significance levels are calculated by multiplying the relative significance matrices in Table 5 and Table 3. These values are also shown in the last column in Table 5. When these figures in the column of total weights are sorted from highest to smallest importance, the most appropriate case-type to select for radiator will be found to be the POE alternative at 0.324.

3.2. Fuzzy AHP Application

According to the Chang method, the fuzzy state of the pairwise comparisons of the criterion shown in table 2 is given in table 6.

Table 6: Fuzzy comparison matrix of criteria

	MA			MH			MKM			KDT			TT		
MA	1.00	1.00	2.00	0.25	0.33	0.50	6.00	7.00	8.00	2.00	3.00	4.00	4.00	5.00	6.00
MH	2.00	3.00	4.00	1.00	1.00	2.00	8.00	9.00	0.00	4.00	5.00	6.00	6.00	7.00	8.00
MKM	0.13	0.14	0.17	0.11	0.11	0.13	1.00	1.00	2.00	0.11	0.11	0.13	0.17	0.20	0.25
KDT	0.25	0.33	0.50	0.17	0.20	0.25	8.00	9.00	9.00	1.00	1.00	2.00	7.00	8.00	9.00
TT	0.17	0.20	0.25	0.13	0.14	0.17	4.00	5.00	6.00	0.11	0.13	0.14	1.00	1.00	2.00

S value is calculated using the matrix in Table 6 (see Table 7), and the likelihood levels of the criteria is demonstrated in Table 8. (Based on the formulas described in section 2.2)

Table 7: Synthesis values of criteria

MA	13.25	16.33	20.50	S_{MA}	0.18	0.24	0.36
MH	21.00	25.00	20.00	S_{MH}	0.29	0.37	0.35
MKM	1.51	1.57	2.67	S_{MKM}	0.02	0.02	0.05
KDT	16.42	18.53	20.75	S_{KDT}	0.23	0.27	0.36
TT	5.40	6.47	8.56	S_{TT}	0.07	0.10	0.15
Total	57.58	67.90	72.48				
k	0.01	0.01	0.02				

Table 8: Likelihood values of criteria

	MA	MH	MKM	KDT	TT
MA		0.35	1.00	0.81	1.00
MH	1.00		1.00	1.00	1.00
MKM	0.00	0.00		0.00	0.00
KDT	1.00	0.41	1.00		1.00
TT	0.00	0.00	1.00	0.00	

In Table 8, the "Matrix of likelihood values", line minimums constitute the fuzzy weights of the criteria. w=(0.35 1 0 0.41 1)

Assuming that w represents the matrix, the sum is: $\sum w$= 0.35+1+0+0.41+1 = 2.76

The weight matrix can be normalized by dividing the elements by the total in the matrix, and thereby; The normalized w values are found as (0.13 0.36 0 0.15 0.36) in which w is not a fuzzy number any longer.

Establishment of Fuzzy Weights for the Alternatives

The next step in the Fuzzy AHP is to make paired fuzzy comparisons of the alternatives based on each criterion and define their order of priority. Here, the criterion of "volume of material" was used to identify the priorities for the alternatives, and likewise the alternatives were prioritized also based on the other four criteria.

The pairwise fuzzy comparisons of the alternatives according to the "volume of material" criterion are shown in Table 9.

Table 10 presents the fuzzy synthesis values of alternatives according to the "volume of material" criterion, and Table 11 also presents the likelihood values.

Table 9: The pairwise fuzzy comparisons of the alternatives according to the "volume of material" criterion

	POA			POC			POD			POG			POE			OO2			OOB			OOD		
POA	1.00	2.00	2.00	0.33	0.50	1.00	0.20	0.25	0.33	0.25	0.33	0.50	0.11	0.11	0.13	0.11	0.11	0.13	0.14	0.17	0.20	0.11	0.13	0.14
POC	1.00	2.00	3.00	1.00	2.00	2.00	0.25	0.33	0.50	0.33	0.50	1.00	0.11	0.13	0.14	0.11	0.13	0.14	0.17	0.20	0.25	0.13	0.14	0.17
POD	3.00	4.00	5.00	2.00	3.00	4.00	1.00	2.00	2.00	1.00	2.00	3.00	0.13	0.14	0.17	0.13	0.14	0.17	0.20	0.25	0.33	0.14	0.17	0.20
POG	2.00	3.00	4.00	1.00	2.00	3.00	0.33	0.50	1.00	1.00	2.00	2.00	0.17	0.20	0.25	0.14	0.17	0.20	0.25	0.33	0.50	0.17	0.20	0.25
POE	8.00	9.00	9.00	7.00	8.00	9.00	6.00	7.00	8.00	4.00	5.00	6.00	1.00	2.00	2.00	0.33	0.50	1.00	3.00	4.00	5.00	2.00	3.00	4.00
OO2	8.00	9.00	9.00	7.00	8.00	9.00	6.00	7.00	8.00	5.00	6.00	7.00	1.00	2.00	3.00	1.00	2.00	2.00	3.00	4.00	5.00	2.00	3.00	4.00
OOB	5.00	6.00	7.00	4.00	5.00	6.00	3.00	4.00	5.00	2.00	3.00	4.00	0.20	0.25	0.33	0.20	0.25	0.33	1.00	2.00	2.00	0.33	0.50	1.00
OOD	7.00	8.00	9.00	6.00	7.00	8.00	5.00	6.00	7.00	4.00	5.00	6.00	0.25	0.33	0.50	0.25	0.33	0.50	1.00	2.00	3.00	1.00	2.00	2.00

Table 10: Fuzzy synthesis values of alternatives

POA	2.26	3.60	4.43	S_{POA}	0.01	0.02	0.03
POC	3.10	5.43	7.20	S_{POC}	0.02	0.03	0.05
POD	7.59	11.70	14.87	S_{POD}	0.04	0.07	0.11
POG	5.06	8.40	11.20	S_{POG}	0.03	0.05	0.08
POE	31.33	38.50	44.00	S_{POE}	0.16	0.22	0.32
OO2	33.00	41.00	47.00	S_{OO2}	0.16	0.24	0.34
OOB	15.73	21.00	25.67	S_{OOB}	0.08	0.12	0.19
OOD	24.50	30.67	36.00	S_{OOD}	0.12	0.18	0.26
Total	122.58	160.29	190.36				
K	0.0053	0.0062	0.0082				

Table 11: Likelihood values of alternatives

	POA	POC	POD	POG	POE	OO2	OOB	OOD
POA		0.50		0.00	0.00	0.00	0.00	0.00
POC	1.00		0.20	0.50	0.00	0.00	0.00	0.00
POD	1.00	1.00		1.00	0.00	0.00	0.38	0.00
POG	1.00	1.00	0.67		0.00	0.00	0.00	0.00
POE	1.00	1.00	1.00	1.00		0.89	1.00	1.00
OO2	1.00	1.00	1.00	1.00	1.00		1.00	1.00
OOB	1.00	1.00	1.00	1.00	0.23	0.20		0.54
OOD	1.00	1.00	1.00	1.00	0.71	0.63	1.00	

In the likelihood values matrix of the alternatives given in Table 11 (according to the "volume of material" criterion), line minimums constitute the fuzzy weights of the alternatives. *w*=(0 0 0 0 0.89 1 0.20 0.63)

Assuming that *w* represents the matrix, the sum is: ∑w= 0+0+0+0+0.89+1+0.20+0.63= 2.72

The weight matrix can be normalized by dividing the matrix elements by the total figure, and thereby; the normalized *w* values are found as (0 0 0 0 0.33 0.37 0.07 0.23) in which *w* is not a fuzzy number any longer.

Weighting the alternatives based on all the criteria is similarly performed that the fuzzy weights for the alternatives can be seen in Table 12.

As seen in Table 13, the product of the criteria and the alternative weights is the weight vector, which is the alternative with the highest score to be selected through the AHP method, namely this case should be chosen as the POE alternative with the score of 0.30.

Table 12: Fuzzy weights for the alternatives

						Weight vector of criteria	0.13	0.36	0.00	0.15	0.36	
Case-type	**MA**	**MH**	**MKM**	**KDT**	**TT**	**Case-type**	**MA**	**MH**	**MKM**	**KDT**	**TT**	**Weight vector**
POA	0.00	0.00	0.00	0.00	0.62	**POA**	0.00	0.00	0.00	0.00	0.15	0.06
POC	0.00	0.00	0.00	0.00	0.69	**POC**	0.00	0.00	0.00	0.00	0.17	0.06
POD	0.00	0.00	0.00	0.00	0.86	**POD**	0.00	0.00	0.00	0.00	0.21	0.08
POG	0.14	0.00	0.00	0.00	0.87	**POG**	0.05	0.00	0.00	0.00	0.22	0.08
POE	1.00	0.89	0.94	0.89	1.00	**POE**	0.34	0.33	0.33	0.35	0.25	**0.30**
OO2	0.82	1.00	1.00	1.00	0.00	**OO2**	0.28	0.37	0.35	0.40	0.00	0.23
OOB	0.59	0.20	0.27	0.00	0.00	**OOB**	0.20	0.07	0.10	0.00	0.00	0.05
OOD	0.40	0.63	0.63	0.63	0.00	**OOD**	0.14	0.23	0.22	0.25	0.00	0.14
TOTAL	2.95	2.72	2.84	2.52	4.04							1

4. Discussion

In the study, we examined the appropriate case-type selection problem to generate solutions to the adverse outcomes, particularly some defects in the raw material quality, due to the misplacement of the raw materials from the suppliers against an automobile manufacturer. In the analysis made together with the procurement specialists, paired comparisons were made between the alternatives or the criteria. The analytical remarks may vary among the specialists for procurement that the comparisons cannot be thought to be exactly objective. When considering a verbal assessment to be easier and more realistic, rather than such a numerical evaluation, the fuzzy comparisons of the alternatives and the criteria were made with the help of purchasing agents again. The case type selection problem has been resolved using either AHP or fuzzy AHP method. The order of priority for types of cases are presented in Table 13, based on both techniques.

Table 13: Prioritization of case-types according to AHP and Fuzzy AHP methods

Case-type	Weight vector	Relative importance	Fuzzy Weight vector	Fuzzy Relative importance
POA	0.056	8	0.06	5
POC	0.062	7	0.06	5
POD	0.086	6	0.08	4
POG	0.093	5	0.08	4
POE	0.312	2	**0.30**	1
OO2	**0.324**	1	0.23	2
OOB	0.116	4	0.05	6
OOD	0.152	3	0.14	3

As seen in Table 13, the OO2-type case is of choice due to its highest score in the AHP solution method while the POE-type case is to be selected for the same reason.

Conclusions

The selection and evaluation of suppliers are strategically important to maintain business success. Many factors have to be considered in running these processes. In this research, the case-type selection problem has been studied, which is a critical function in supply management system. In order to solve this problem, AHP, one of multi-criteria decision making techniques, was used since there are many considerations to select the best type among the case options. The numerical evaluation is not always effective to make paired comparisons, and thus fuzzy AHP method is applied for the problem solving, through which fuzzy assessment is performed. AHP and fuzzy AHP was found to be the optimum techniques for case-type selection. According to the results shown in Table 13, the OO2-type case should be selected based on the solution of AHP while the case of choice in fuzzy AHP is the POE-type one, which is the second option in AHP, whereas the other comes off second-best in the fuzzy AHP model.

References

[1] R. Kumar, S. S. Padhi, A. Sarkar, *"Supplier Selection of an Indian Heavy Locomotive Manufacturer: An Integrated Approach using Taguchi Loss Function, TOPSIS and AHP"*, IIMB Management Review, https://doi.org/10.1016/j.iimb.2018.08.008, 2018

[2] M. Abd el-Basset, G. Manogaran, M. Mohamed, N. Chilamkurti *"Three-way decisions based on neutrosophic sets and AHP-QFD framework for supplier selection problem"*, Future Generation Computer Systems, 89, pp 19-30, 2018

[3] A. Azimifard, S. H. Moosavirad, S. Ariafar *"Selecting sustainable supplier countries for Iran's steel industry at three levels by using AHP and TOPSIS methods"*, Resources Policy 57, pp 30-44, 2018

[4] A. Awasthi, K. Govindan, S. Gold *"Multi-tier sustainable global supplier selection using a fuzzy AHP-VIKOR based approach"* International Journal of Production Economics 195, pp 106-117, 2018

[5] P. Sirisawat, T. Kiatcharoenpol *"Fuzzy AHP-TOPSIS approaches to prioritizing solutions for reverse logistic barriers"* Computers&Industrial Engineering 117,pp303-318, 2018

[6] S. K. Patil, R. Kant *"A fuzzy AHP-TOPSIS framework for ranking the solutions of Knowledge Management adoption in Supply Chain to overcome its barriers"* Expert Systems with Applications 41, pp 679-693, 2014

[7] M. Dağdeviren, T. Eren *"Tedarikçi Firma Seçiminde Analitik Hiyerarşi Prosesi ve 0-1 Hedef Programlama Yöntemlerinin Kullanılması"* Gazi Üniv. Müh. Mim. Fak. Der. Cilt 16, No 2, 41-52, 2001

[8] S.Soner, S.Önüt *"Multi-criteria supplier selection: An Electre-Ahp application"* Journal of Engineering and Natural Sciences-Müh. ve Fen Bilimleri Dergisi-Sigma4, 2006

[9] R. W. Saaty *"The Analytic Hierarchy Process – What it is and how it is used"* Math Modelling, vol. 9, No 3-5 pp 161-176, 1987

[10] M. S. Yıldız, S. Aksoy *"Analitik Hiyerarşi Prosesi ile Personel Seçimi Üzerine bir Çalışma"*, AİBÜ Sosyal Bilimler Enstitüsü Dergisi, cilt: 15, sayı: 1, ss 59-83, 2015

[11] B.F. Yıldırım, E. Önder, *"İşletmeciler, Mühendisler ve Yöneticiler için Operasyonel, Yönetsel ve Stratejik Problemlerin Çözümünde Çok Kriterli Karar Verme Yöntemleri"*, Dora Yayıncılık, 2nd Edition, Printed in Bursa, ISBN: 978-605-9929-44-8

[12] Ş. Gür, M. Hamurcu, T. Eren *"Ankara'da Monoray projelerinin analitik hiyerarşi prosesi ve 0-1 hedef programalama yöntemleri ile seçimi"* Pamukkale Üniversitesi Mühendislik Bilimleri Dergisi, 23(4), ss 437-443, 2017

[13] H. Çanlı, A.Kandakoğlu, *"Hava Gücü Mukayesesi için Bulanık AHP Modeli"*, Havacılık ve Uzay Teknolojileri Dergisi, cilt: 3, sayı: 1, ss 71-82, 2007s

[14] Ö. Aydın *"Bulanık AHP ile Ankara için Hastane Yer Seçimi"* Dokuz Eylül Üniversitesi İktisadi İdari Bilimler Fakültesi Dergisi, cilt: 24, sayı:2, ss 87-104, 2009

[15] A. Şimşek, O. Catır, N. Ömürbek *"Turizm sektöründe bulanık analitik hiyerarşi süreci ile personel seçimi"* Uludağ Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, cilt:XXXIII, sayı: 2, ss 147-169, 2014

[16] D. Kaptanoğlu, A.F. Özok *"Akademik Performans Değerlendirmesi için bir Bulanık Model"* İTÜ Dergisi – Mühendislik, cilt: 5, sayı: 1 ss 193-204, 2006