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Using the Fuzzy AHP methodology in Customer's Purchasing Decision-making Process based on Marketing Mix (4Ps)

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Abstract

In purchasing process, whether in traditional or online, we face the problem of comparison and decision-making. Also given the fact that the main criteria which are considered by most customers in purchasing process are marketing mix (4Ps), so we take into consideration these criteria as the main criterion. Moreover, lack of certainty and definability of these criteria in fuzzy form lead us to model customer's purchasing decision-making process by using the fuzzy AHP methodology.

Keywords: Fuzzy AHP, Marketing Mix (4Ps), Customer's Purchasing Decision-Making Process

I. INTRODUCTION :

We are face decision-making and selecting (goods) during the day and do it continuously in our life. In decision-making issue, we always face choosing one option from various options as related criteria and then we make a decision. One of the aspects of decision-making which people, organizations and managers of industrial plants encounter is decision-making about purchasing required goods and

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equipment. Estimated criteria in this process have been considered in numerous studies. [1] In purchasing process, criteria are different from buyer and seller's point of view and each of them try to maximise their profit rate, and criteria which are commonly considered between them is called marketing mix which expressed by Kotler and Borden in 1964. [2] After that, many other people did some research in this respect. [3] other people examined the criteria of marketing mix and considered those criteria for different times. [4]. But as regards to all studies and research which have been done, it can be observed that the only criteria which is expressed and estimated in all studies and research is marketing mix (4Ps). Buyers and customers most consider these criteria in other aspects and based on them, they decide about purchasing. These criteria are just **price**, quality characteristics or **product**, purchasing **place** and **promotion**. Also research have been done regarding using method and degree of importance of these criteria and transposition of these criteria estimations of options and decision-making in purchasing issue are explained.[5] Now regarding the uncertainty of these criteria and also considering that these criteria should be estimated in ranges and limits which are present through different sellers, they can be represented in fuzzy form and decisions are made based on these fuzzy criteria.

Finally, there are different prices, different qualities and features, various supply places, numerous services and side advantages for a certain or special goods which make some problems decision-making purchasing suitable goods. By considering the high level of uncertainty and fuzziness of the criteria the problem of decision-making is doubled. Our suggested method for solving this problem is to use FAHP(Fuzzy AHP)technique, which based on the decision-maker can have the best selection.

The following chapter, the suggested model and one operational case of purchasing decision-making are presented.

II. Proposed model :

For **price** as a criteria, which is considered as the most important parameter in decision-making for purchasing, it can be expressed that regarding variation of prices and also putting them in a span, it is defined in the form of a triangular fuzzy number. Also it can be noted that the price which has an important role for decision-maker, sometimes is changeable with regards to other features presented, but it has a certain and acceptable span for decision-maker, E.g, this definition has been considered in works that have been done for presenting intelligent (automotive) purchasing agent. [6]

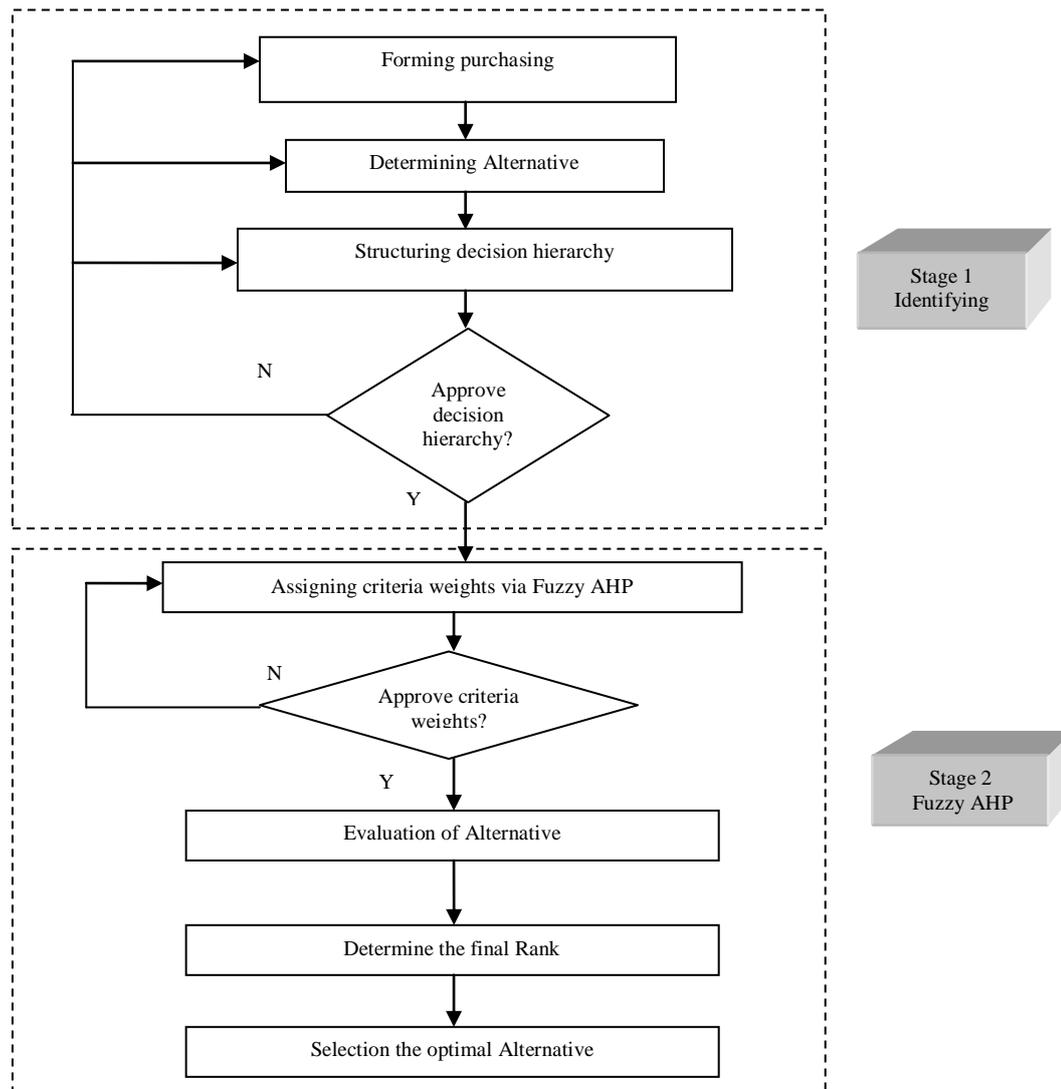


Figure 1 : Schematic diagram of the proposed model for selection.

The same argumentation also can be expressed about other criteria considering its uncertain state and available conditions in dominant environment at purchasing issue. About the **product** features the main objective which is considered is the good's quality .[7],[8] . By expressing our qualitative issues in this study in fuzzy form and by considering their importance in decision-making hierarchy, we get to estimation.

But about the **place** of purchasing the goods, distance of supply places and the time taken for customers to receive the goods should be considered. Because of the dependence of the criteria to the very important and effective factor of lead time(LT) and because this factor is fuzzy, the goods supply site can be considered in triangular fuzzy number and it can be used in decision-making hierarchy structure.

As for side effects or **promotion**, some factors such as flexibility in giving services, guarantee, receiving and installation costs, etc. are effective and should be considered in fuzzy form.

To have suitable selection in purchasing process, we should consider 2 steps. In below the first step, we should identify available options and also we should determine criteria, based on which decision-making is done and which are here the same (4Ps) criteria. Then we should form decision hierarchy and in the case of accepting the steps mentioned above, we can consider the next step which is determining of the best option by using fuzzy AHP technique. (Fig.1).

III. Fuzzy AHP Methodology :

The Analytic Hierarchy Process (AHP) is a powerful and flexible decision-making process (Saaty, 1980)[9] to help Decision-makers set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered. By reducing complex decisions to a series of one-on-one comparisons, then synthesizing the results, many researchers have concluded that AHP is a useful, practical and systematic method for rating (Barbarosoglu and Yazgac, 1997)[10]; it has certainly, been applied successfully. However, in many practical cases the human preference model is uncertain and decision-makers might be reluctant or unable to assign exact numerical values to the comparison judgments. For instance, when evaluating different purchases, the decision-makers are usually unsure about their level of preference due to incomplete and uncertain information about possible purchases and their performances. Since some of the purchases evaluation criteria are subjective and qualitative, it is very difficult for the decision-maker to express the strength of his / her preferences and to provide exact pair-wise comparison judgments. For this reason, a methodology based on fuzzy AHP can help us to reach an effective decision (Bellman and Zadeh, 1970)[11]. By this way we can deal with the uncertainty and vagueness in the decision process .

Fuzzy AHP consists of deriving the local priorities from these fuzzy preference ratios, which are subsequently aggregated to form the global priorities. The fuzzy AHP computes fuzzy priorities based on arithmetic operations for fuzzy triangular (or trapezoidal) numbers. To be able to use the fuzzy arithmetic operations, specific assumptions on the forms of membership functions are required. However, the most important criticism directed at fuzzy arithmetic operations is their failure to address the issue of consistency. There is no explicit articulation on what would constitute an inconsistent comparison matrix within the fuzzy AHP context and, equally important, on how inconsistent information should be handled .

Lacking a mechanism to exclude inconsistent data, fuzzy priorities so obtained are likely to be flawed (Zimmerman, 1991[12]; Buckley, Feuring, and Hayashi, 2001)[13]. In addition to combining the AHP approach with other methods, Zaim et al. (2003)[14] has discussed fuzzy analytic hierarchy based approach for purchase selection in the area of marketing. Chen et al. (2006)[15] also employed hierarchical model using triangular fuzzy numbers to deal with purchase selection problems.

In this study, the framework of feasible regions of relative weights was adopted. Firstly, allowing the feasible region to include tolerance deviations of the fuzzy ratios, we define fuzzy consistency as the existence of relative weights within the region. Secondly, we devise a maximum/minimum set ranking method to derive a crisp ranking from the global fuzzy weights (Noci and Toletti, 2000[16];

Leung and Cao 2000)[17] , The following steps of Fuzzy AHP proposed by Chang (1996)[18] have been utilized selecting purchases in the multi-period phase .

According to the method of Chang’s extent analysis, each object is taken and extent analysis for each goal is performed respectively. Therefore m extent analysis values for each object can be obtained, with the ,following signs :

$$M_{gi}^1, M_{gi}^2, \dots, M_{gi}^m, i = 1, 2, \dots, n$$

Where M_{gi}^j ($j = 1, 2, \dots, m$) all are TFNs. The steps of Chang’s extent analysis (Chang, 1996)[18] can be given as in the following:

Step 1 : The value of fuzzy synthetic extent with respect to the i th object is defined as

$$S_i = \sum_{j=1}^m M_{gi}^j \otimes \left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1} \tag{1}$$

To obtain $\sum_{j=1}^m M_{gi}^j$, the fuzzy addition operation of m extent analysis values for a particular matrix is performed such as

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

And to obtain $\left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]$, by performing the fuzzy addition operation of M_{gi}^j ($j = 1, 2, \dots, m$) such that

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

And $\left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1}$ can be calculated by the inverse of Eq.(3), as follows :

$$\left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1} = \left(\frac{1}{\sum_{i=1}^n u_i}, \frac{1}{\sum_{i=1}^n m_i}, \frac{1}{\sum_{i=1}^n l_i} \right) \tag{4}$$

Step 2 : as $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ are two triangular fuzzy numbers, the degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is defined as

$$V (M_2 \geq M_1) = \sup_{y \geq x} [\min(\mu_{M_1}(x), \mu_{M_2}(y))] \tag{5}$$

and can be expressed as follows :

$$V (M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d) \tag{6}$$

$$= \left\{ \begin{array}{ll} 1 & \text{if } m_2 \geq m_1 \\ 0 & \text{if } l_1 \geq u_2 \\ \frac{(l_1 - u_2)}{(m_2 - u_2) - (m_1 - l_1)} & \text{otherwise} \end{array} \right\} \quad (7)$$

Fig.2 illustrates Eq. (6) where d is the ordinate of the highest intersection point D between μ_{M_1} and μ_{M_2} . To compare $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$, we need both the values of $V (M_1 \geq M_2)$ and $V (M_2 \geq M_1)$.

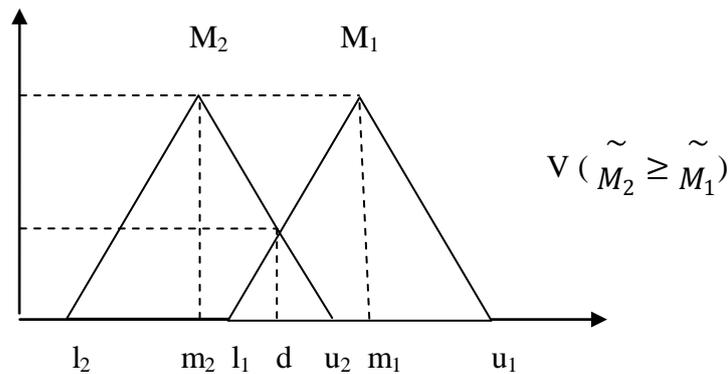


Fig. 2 : Intersection between M_1 and M_2 (Kahraman et al., 2004)

Step 3 : The degree possibility for a convex fuzzy number to be greater than k convex fuzzy $M_i (i = 1, 2, \dots, k)$ numbers can be defined by

$$\begin{aligned} V (M \geq M_1, M_2, \dots, M_k) &= v [(M \geq M_1) \text{ and } (M \geq M_2) \text{ and } (M \geq M_k)] \\ &= \min v (M \geq M_i), i = 1, 2, \dots, k \end{aligned} \quad (8)$$

Assume that

$$d(A_i) = \min V (S_i \geq S_k) \text{ for } k = 1, 2, \dots, n ; k \neq i \quad (9)$$

Then the weight vector is given by

$$w = (d(A_1), d(A_2), \dots, d(A_n))^T \quad (10)$$

Where $A_i (i=1, 2, \dots, n)$ are the n elements.

Step 4 : Via normalization, the normalized weight vectors are

$$w = (d(A_1), d(A_2), \dots, d(A_n))^T \quad (11)$$

Where W is a non- fuzzy number.

4. An Illustrative Example :

This numerical example presents a mathematical model to select alternative in a multi-period environment.

4.1. Define the criteria for purchase selection

The main objective is the selection of the best purchase in a dynamic environment. The decision-makers can estimate the relative weights - ratios for each pair of alternatives under every attribute as well as the relative weights ratios for the attributes .Application of common criteria to all purchases makes objectives comparisons possible. The criteria considered here in selection of the best purchase in a dynamic environment are:

- Price (Product cost, Transportation cost, Development & tooling cost)
- Product (Quality, Installation ease, Life cycle, Characteristics)
- Place (Lead time, Distance)
- Promotion (Guarantee, Flexibility of service)

The hierarchy of the selection criteria and decision alternatives (i.e., purchases) in dynamic environment can be seen in Fig. 3. In the hierarchy, the overall objective (i.e., the best purchase) is placed at level 1 ,criteria at level 2, and the purchases alternatives at level 3.

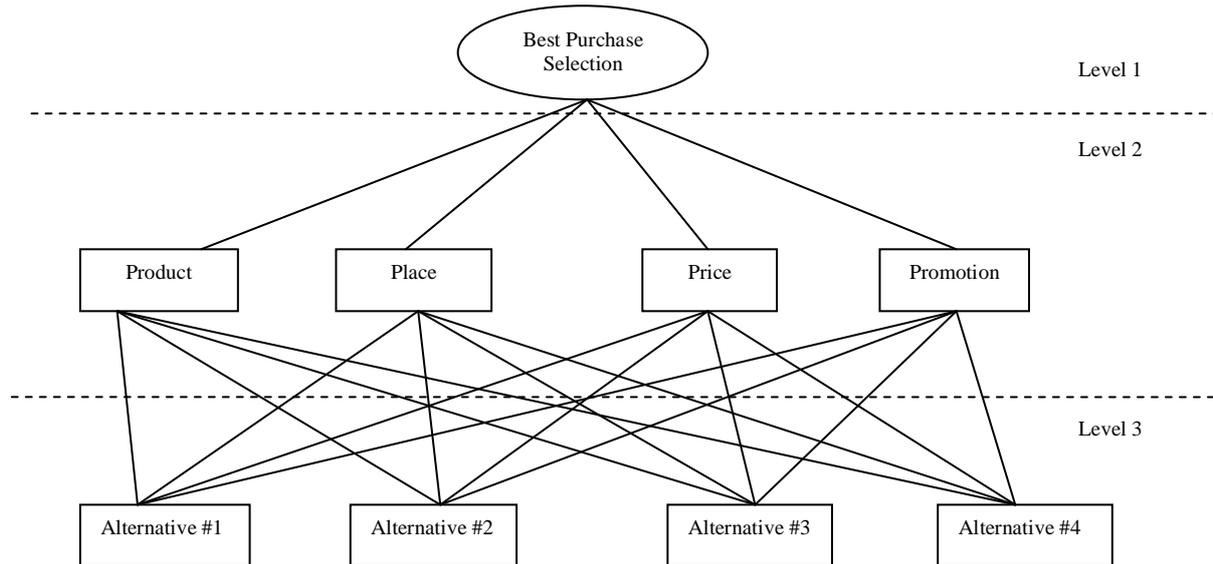


Figure 3: Hierarchy for purchase selection

The above mentioned criteria help in deciding the best selection in Customer’s Purchasing Decision-making Process (CPDP). The preferences of one over other have been decided by the decision-makers. The human judgment may not always be crisp and hence the evaluation scale, used by decision-makers, is illustrated in Table 1 .

Table 1: FAHP scale

Definition	Intensity of importance
Equal	(1,1,1)
Weak	(2/3,1,3/2)
Fairly strong	(3/2,2,5/2)
Very strong	(5/2,3,7/2)
Absolute	(7/2,4,9/2)

The fuzzy pair wise reciprocal judgments matrix by the decision-maker for each criterion, with respect to overall objective (i.e., selecting the best purchase; (see Table 2), and for each purchase with each of the criterion (see Tables 3–6), are determined in each of the three periods by the help of FAHP scale defined in Table 1.

Table 2: The Criterion fuzzy pair wise comparison matrix.

	Product	Place	Price	Promotion
Product	(1,1,1)	(5/2,3,7/2)	(3/2,2,5/2)	(3/2,2,5/2)
Place	(2/7,1/3,2/5)	(1,1,1)	(2/5,1/2,2/3)	(2/3,1,3/2)
Price	(2/5,1/2,2/3)	(3/2,2,5/2)	(1,1,1)	(3/2,2,5/2)
Promotion	(2/5,1/2,2/3)	(2/3,1,3/2)	(2/5,1/2,2/3)	(1,1,1)

Table 3: The alternatives fuzzy pair wise comparison matrix with respect to criteria Product.

Product	Purchase 1	Purchase 2	Purchase 3	Purchase 4
Purchase 1	(1,1,1)	(2/3,1/2,3/2)	(3/2,2,5/2)	(3/2,2,5/2)
Purchase 2	(2/3,1,3/2)	(1,1,1)	(2/5,1/2,2/3)	(2/3,1,3/2)
Purchase 3	(2/5,1/2,2/3)	(3/2,2,5/2)	(1,1,1)	(2/5,1/2,2/3)
Purchase 4	(2/5,1/2,2/3)	(2/3,1,3/2)	(3/2,2,5/2)	(1,1,1)

Table 4: The alternatives fuzzy pair-wise comparison matrix with respect to criteria Place

Place	Purchase 1	Purchase 2	Purchase 3	Purchase 4
Purchase 1	(1,1,1)	(2/9,1/4,2/7)	(2/3,1,3/2)	(2/5,1/2,2/3)
Purchase 2	(7/2,4,9/2)	(1,1,1)	(3/2,2,5/2)	(3/2,2,5/2)
Purchase 3	(2/3,1,3/2)	(2/5,1/2,2/3)	(1,1,1)	(2/3,1,3/2)
Purchase 4	(3/2,2,5/2)	(2/5,1/2,3/2)	(2/3,1,3/2)	(1,1,1)

Table5: The alternatives fuzzy pair-wise comparison matrix with respect to criteria Price

Price	Purchase 1	Purchase 2	Purchase 3	Purchase 4
Purchase 1	(1,1,1)	(3/2,2,5/2)	(3/2,2,5/2)	(2/3,1,3/2)
Purchase 2	(2/5,1/2,2/3)	(1,1,1)	(1,1,1)	(3/2,2,5/2)
Purchase 3	(2/5,1/2,2/3)	(1,1,1)	(1,1,1)	(2/5,1/2,2/3)
Purchase 4	(2/3,1,3/2)	(2/5,1/2,2/3)	(2/5,1/2,2/3)	(1,1,1)

Table6: The alternatives fuzzy pair-wise comparison matrix with respect to criteria Promotion

Promotion	Purchase 1	Purchase 2	Purchase 3	Purchase 4
Purchase 1	(1,1,1)	(2/9,1/4,2/7)	(2/3,1,3/2)	(2/5,1/2,2/3)
Purchase 2	(7/2,4,9/2)	(1,1,1)	(3/2,2,5/2)	(3/2,2,5/2)
Purchase 3	(2/3,1,3/2)	(2/5,1/2,2/3)	(1,1,1)	(2/3,1,3/2)
Purchase 4	(3/2,2,5/2)	(2/5,1/2,2/3)	(2/3,1,3/2)	(1,1,1)

For identifying the computation procedures, the pair-wise judgments from the Table 3 are evaluated as follows:

$$\text{Purchase}_{1\text{product}} = (4.667, 6, 7.5) \otimes (1/20.00, 1/18.00, 1/14.267) = (0.2333, 0.333, 0.526)$$

$$\text{Purchase}_{2\text{product}} = (2.733, 3.5, 4.667) \otimes (1/20.00, 1/18.00, 1/14.267) = (0.137, 0.194, 0.327)$$

$$\text{Purchase}_{3\text{product}} = (3.30, 4, 4.833) \otimes (1/20.00, 1/18.00, 1/14.267) = (0.165, 0.222, 0.339)$$

$$\text{Purchase}_{4\text{product}} = (3.567, 4.5, 4.667) \otimes (1/20.00, 1/18.00, 1/14.267) = (0.178, 0.250, 0.327)$$

After determining these results, these fuzzy values are compared by using Eq. (7)

$$V(\text{Purchase}_{1\text{product}} \geq \text{Purchase}_{2\text{product}}) = 1$$

$$V(\text{Purchase}_{1\text{product}} \geq \text{Purchase}_{3\text{product}}) = 1$$

$$V(\text{Purchase}_{1\text{product}} \geq \text{Purchase}_{4\text{product}}) = 1$$

$$V(\text{Purchase}_{2\text{product}} \geq \text{Purchase}_{1\text{product}}) = 0.402$$

$$V(\text{Purchase}_{2\text{product}} \geq \text{Purchase}_{3\text{product}}) = 0.853$$

$$V(\text{Purchase}_{2\text{product}} \geq \text{Purchase}_{4\text{product}}) = 0.727$$

$$V(\text{Purchase}_{3\text{product}} \geq \text{Purchase}_{1\text{product}}) = 0.484$$

$$V(\text{Purchase}_{3\text{product}} \geq \text{Purchase}_{2\text{product}}) = 1$$

$$V(\text{Purchase}_{3\text{product}} \geq \text{Purchase}_{4\text{product}}) = 0.851$$

$$V(\text{Purchase}_{4\text{product}} \geq \text{Purchase}_{1\text{product}}) = 0.528$$

$$V(\text{Purchase}_{4\text{product}} \geq \text{Purchase}_{2\text{product}}) = 1$$

$$V(\text{Purchase}_{4\text{product}} \geq \text{Purchase}_{3\text{product}}) = 1$$

Then priority weights are calculated by using Eq. (8):

$$d(\text{Purchase}_{1\text{product}}) = \min(1, 1, 1) = 1$$

$$d(\text{Purchase}_{2\text{product}}) = \min(0.402, 0.853, 0.727) = 0.402$$

$$d(\text{Purchase}_{3\text{product}}) = \min(0.484, 1, 0.851) = 0.484$$

$$d(\text{Purchase}_{4\text{product}}) = \min(0.528, 1, 1) = 0.528$$

Therefore, the weight vector from Table 3 is calculated as :

$$w_{\text{product}}^{\text{purchase}} = (1, 0.402, 0.484, 0.528)$$

After the normalization of these values priority weights with respect to criteria Product are calculated as :

$$w_{\text{product}}^{\text{purchase}} = (0.414, 0.167, 0.200, 0.219)$$

The same systematic approach is considered for the other evaluations, and priority weights are expressed

Correspondingly in Tables 7 as follows.

4.2. Results

As we can see the priority of product is important for all alternatives. We can also observe from the table 7 that the price is more important than the place and promotion.

Table 7: The priorities weights of Criteria

Criteria	priorities weights
Product	0.47
Place	0.15
Price	0.25
Promotion	0.14

Table 9: The priorities weights of suppliers with respect to all criteria

Criteria	Product	Place	Price	Promotion
Purchase 1	0.48	0.31	0.38	0.00
Purchase 2	0.17	0.69	0.27	0.85
Purchase 3	0.35	0.00	0.00	0.00
Purchase 4	0.00	0.00	0.35	0.15

Table 10 represents the priority weights of the four Alternatives

Alternative	priorities weights
1	0.367
2	0.370
3	0.165
4	0.109

5. Conclusions:

Obviously, for different decision-makers the alternatives priorities weights may change. This paper

Proposes a dynamic approach based on Fuzzy AHP for purchase selection problems that can help us to reach an effective decision. By this way we can deal with the uncertainty and vagueness in the decision process.

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