Journal of Business and Economics, ISSN 2155-7950, USA
March 2012, Volume 3, No. 3, pp. 234-240

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Selecting the Software that Will Be Developed for the Purchasing Department Using Fuzzy AHP

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Abstract: In a company to manage operations efficiently, software applications have great importance. When the software application has decided to develop, there are lots of factors that influence this process. Hence the decision must be done using a more definite way like using multiple criteria decision making techniques. MCDM techniques are the most effective techniques to achieve the most appropriate decision when there are lots of criteria. In this study, firstly the lacks of the software application which has been using in purchasing department will be determined and then the most effective software application platform will be selected to develop applications by Fuzzy AHP which is one of MCDM techniques.

Key words: multi criteria decision making; fuzzy AHP; software application platform
JEL codes: D81

1. Introduction

Analysis with single parameter or criterion is not enough to resolve the complex structured problem parallel to the development of science and technology. The most significant inference of the single-criteria analysis is to accept the other dimensions of the event as static and examining only one factor for each time. However, the events and the objects occur under the influences of a huge amount of internal and external factors instead of a solitary factor and demonstrate complex formation. Because of this reason, events and objects must be defined according to the amount of agents and their collective efficiency rather than a single agent (Daşdemir İ. & Güngör E., 2005).

2. Multiple Criteria Decision Making

Multi criteria decision making has been one of the fastest growing areas during at least the last two decades. In business decision making has changed over the last decades. From a single person (Boss) and a single criterion (Profit), decision environments have developed increasingly to become multi-person and multi-criteria situations. The awareness of this development is growing in practice. In theory many methods have been proposed and developed since the sixties to solve this problem in numerous ways (Triantaphyllou E., 2000).

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In general, there exist two distinctive types of MCDM problems due to the different problems settings: one type having a finite number of alternative solutions and the other an infinite number of solutions. Normally in problems associated with selection and assessment, the number of alternative solutions is limited. In problems related to design, an attribute may take any value in a range. Therefore the potential alternative solutions could be infinite. If this is the case, the problem is referred to as multiple objective optimization problems instead of multiple attribute decision problems (Xu Ling & Yang Jianbo, 2001).

3. Fuzzy AHP Methodology

3.1 Fuzzy AHP

Analytic hierarchy process (AHP) has been widely used as a useful multiple criteria decision making (MCDM) tool or a weight estimation technique in many areas such as selection, evaluation, planning and development, decision making, forecasting, and so on. The traditional AHP requires crisp judgments. However, due to the complexity and uncertainty involved in real world decision problems, a decision maker (DM) may sometimes feel more confident to provide fuzzy judgments than crisp comparisons (Wang M. Y., Ying L. & Hua Z., 2008). Among these, the fuzzy analytic hierarchy process (FAHP) is one of the most popular of methods have been developed to handle fuzzy comparison matrices. The Fuzzy-AHP methodology extends Saaty's AHP by combining it with the fuzzy set theory. In the Fuzzy-AHP, fuzzy ratio scales are used to indicate the relative strength of the factors in the corresponding criteria. Therefore, a fuzzy judgment matrix can be constructed. The final scores of alternatives are also represented by fuzzy numbers. The optimum alternative is obtained by ranking the fuzzy numbers using special algebra operators.

There are many fuzzy AHP methods proposed by various authors (Bozbura F. T., Beskese A. & Kahraman C., 2006). Chang introduces a new approach for handling fuzzy AHP, with the use of triangular fuzzy numbers for pairwise comparison scale of fuzzy AHP, and the use of the extent analysis method for the synthetic extent values of the pairwise comparisons (Chang D. Y., 1996). In this study, the Chang's method was studied.

3.1.1 Algorithm

Let $X = \{x_1, x_2, \ldots, x_n\}$ be an object set, and $U = \{u_1, u_2, \ldots, u_m\}$ be a goal set. According to the method of Chang's extent analysis, each object is taken and extent analysis for each goal, g_i, is performed, respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$$M_{g_i}^{1}, M_{g_i}^{2}, \ldots, M_{g_i}^{m}, \quad i = 1, 2, \ldots, n \tag{1}$$

Where all the $M_g^j (j = 1,2,\ldots,m)$ are TFNs. The steps of Chang's extent analysis can be given as in the following [3]:

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

$$S_i = \sum_{j=1}^{m} M_{g_i}^{j} \quad \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{1} \tag{2}$$

To obtain $\sum_{j=i}^{m} M_{g_i}^{j}$; perform the fuzzy addition operation of m extent analysis values for a particular matrix such that

$$\sum_{j=i}^{m} M_{g_i}^{j} = \sum_{j=1}^{m} l_j \sum_{j=1}^{m} m_j \sum_{j=1}^{m} u_j \tag{3}$$

and to obtain $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{1}$ perform the fuzzy addition operation of $M_{g_i}^{j}$ (j=1,2,....,m) values such that

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j} = \sum_{j=1}^{m} l_i \sum_{j=1}^{m} m_i \sum_{j=1}^{m} u_i \tag{4}$$

is calculated. And then compute the inverse of the following vector

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \tag{5}$$

Step 2: The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ defined as:

$$V(M_2 \geq M_1) = \sup_{y \geq x} \left[\min(\mu_{M1}(x), \mu_{M2}(y))\right] \tag{6}$$

and can be equivalently expressed as follows:

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M2}(d) \tag{7}$$

$$V(M_2 \geq M_1) = \begin{cases} 1 & ; \quad m_2 \geq m_1 \\ 0 & ; \quad l_1 \geq u_2 \\ \dfrac{(l_1 \quad m_1)}{(m_2 \quad u_2) \quad (m_1 \quad l_1)} & ; \quad otherwise \end{cases} \tag{8}$$

Where d is the ordinate of the highest intersection point D between μ_{M1} and μ_{M2}.

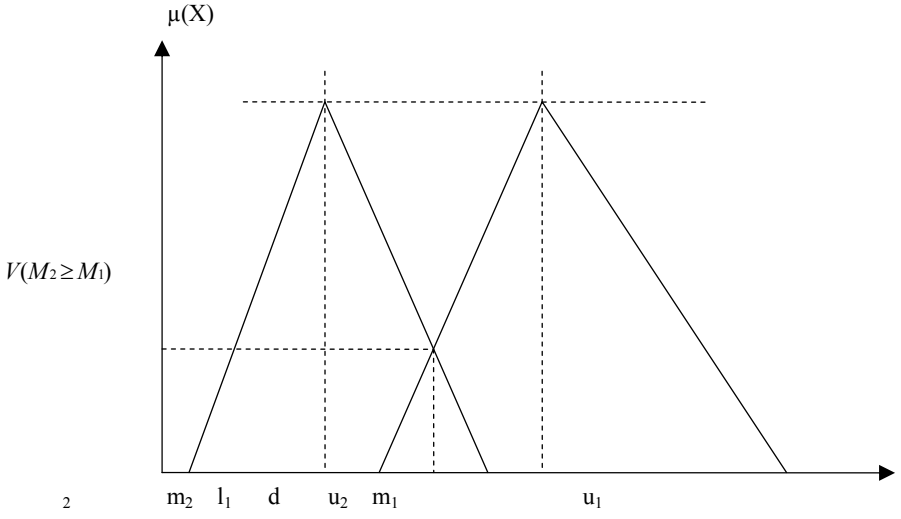

Figure 1 Definition of the degree of possibility [7]

To compare M_1 and M_2; we need both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$.

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

$$V(M \geq M1, M2, ..., Mk) = \min V(M \geq Mi) \quad (i=1,2,....,k) \tag{9}$$

(i =1,2,....,k) and k≠i ;

Assume that

$$d'(Ai) = \min V(S_i \geq S_k) \tag{10}$$

Then the weight vector is given by

$$W' = (d'(A_1), d'(A_2), ..., d'(A_n))^T \tag{11}$$

Where A_i (i=1,2,...,n) are n elements.

Step 4: Via normalization, the normalized weight vectors are

$$W = (d(A_1), d(A_2), ..., d(A_n)) \tag{12}$$

Where W is a non-fuzzy number. [1]

4. Case Study

Purchasing department needs a new software application to use for customer requirements. We use the Fuzzy AHP methodology and Point Saaty scale to rank the project alternatives because criteria will evaluated to fuzzy triangular number.

Firstly the decision model outline of case study is decided. After defined the outline of project lacks of the Software application is determined: Customer Information, Supplier Information and products, Demands, Offering, Reporting Service, Special offers to customers in the system will be created by making data mining.

There are two alternatives for the software application platform: Software Development (SD) (That alternative is developing a new software application using programming language and database), Using Package Programing as CRM (PP) (That alternative is developing an application using a package programming like CRM. On that alternative we don't use any programming language, but there is customization of package programming).

4.1 Defining of Attributes in Selecting of SD, PP

The method of Fuzzy AHP is used for selecting of the best software application platform. In this method, firstly the factors' fuzzy weights are calculated according to each other for selecting of SD, PP. Firstly attributes that is characteristic for selecting of software application platforms must be listed. For two platforms, attributes are: Software Technology and Software Performance, Flexibility, Cost, Service Level.

Attributes are parted to sub attributes that are important for software platforms.

(1) Software Technology and Software Performance(S): Software Development and Easiness of Software Usage(SDU), Speed of Software Working(SS), Software Security and Software Credibility(SSC), Technical Sufficiency(TS), Based on Internet(BI) , Easiness of software installation(ESI)

(2) Flexibility(F): The development of user-friendly interface(DFI), flexible and interactive reporting(FIR), customization for business processes(CBP)

(3) Cost(C): Licensing Fee (LF)

(4) Service Level (SL): Velocity of Support after Sale (SV), Sufficiency of Support Department after Sale (SDS), Online Help after Sale (OH)

A survey is made in Company to establish importance weights (fuzzy preference numbers) that are necessary for selecting of best card technology. The survey facilitates the answers of pairwise comparison of questions.

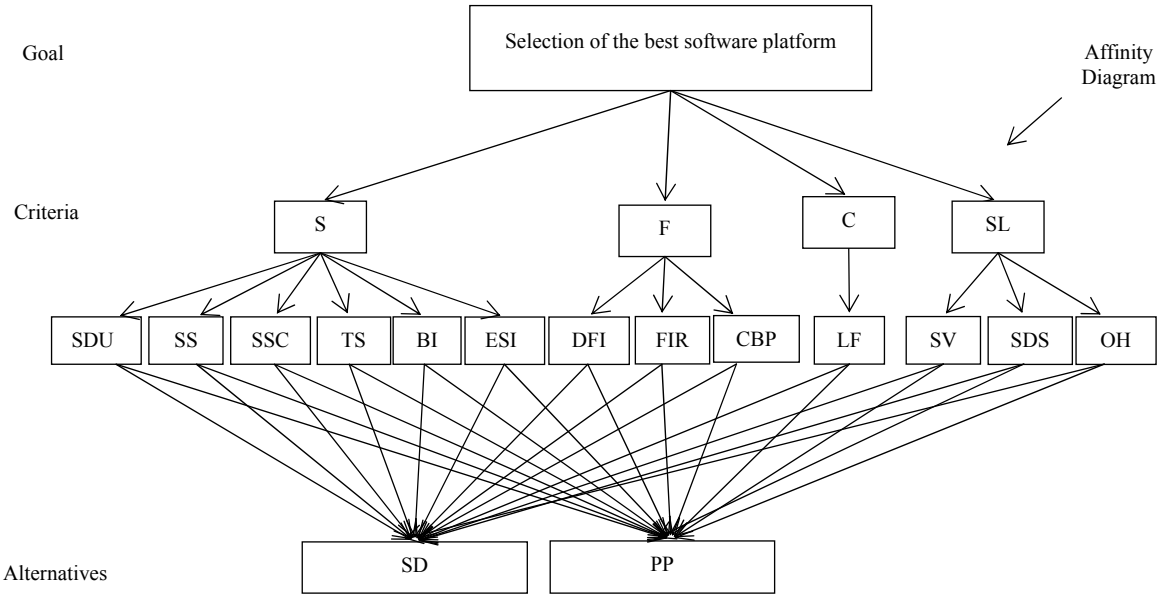

Figure 2 Hierarchy of the Problem

4.2 Survey

The survey was made with three person worked at the department of Software and System analysis in the case company. Following questions show example questions about the pairwise comparison matrix:

- ✓ Question 1: How important is S when it is compared with F?
- ✓ Question 2: How important is S when it is compared with C?

...

Other matrices are done with same method.

Table 1 Evaluation of the Attributes

Selecting of Software Platform		The fuzzy evaluation matrix with respect to the goal									
Questions	Attributes	Absolute (7/2,4,9/2)	Very Strong (5/2,3,7/2)	Fairly Strong (3/2,2,5/2)	Weak (2/3,1,3/2)	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)	Attributes
Q1	S		X	XX							F
Q2	S		XX	X							C

The importance of Software technology and software performance when it is compared with Flexibility is very strong and twice fairly strong.

Table 2 Pairwise Comparisons—Alternative

Software Development and Easiness of Software Usage		Importance (or preference) of one alternative over another									
Questions	Attributes	(7/2,4,9/2) Absolute	(5/2,3,7/2) Very Strong	(3/2,2,5/2) Fairly Strong	(2/3,1,3/2) Weak	(1,1,1) Equal	(2/3,1,3/2) Weak	(3/2,2,5/2) Fairly Strong	(5/2,3,7/2) Very Strong	(7/2,4,9/2) Absolute	Attributes
Q 26	SD							XXX			PP

4.3 Calculation

For determining the relative importance between elements, the members of committee were asked to respond

through a series of pairwise comparisons with Saaty's nine-point scale. According to result of questionnaire, geometric mean is used to set a series of pairwise comparisons.

Fuzzy synthetic degrees are calculated importance weights of attributes are calculated by usage of fuzzy synthetic degrees. From the formula; importance weights of attributes are calculated by usage of fuzzy synthetic degrees. Probability of preference of one to other is calculated. From this, the weight vector is calculated. The normalized weight vectors are values that are used from select of smart card technologies. You can see some Fuzzy synthetic degrees on Table 3.

Table 3 Fuzzy Synthetic Degrees

Fuzzy Synthetic Degrees				
		I	m	u
Main Attributes	S1	0.30	0.40	0.58
	S2	0.15	0.20	0.29
	S3	0.10	0.12	0.17
	S4	0.21	0.23	0.41

Normalized value of each criterion is multiplied by corresponding normalized alternative value and then they are summed up.

Table 4 Weights of Alternatives for Sub-Attributes of S

	SDU	SS	SSC	TS	BI	ESI	Alternative Priority Weight
Weight	0.1	0	0.38	0.22	0.29	0	
Alternatives							
SD	1	1	0.6	0.78	0.5	1	0.65
PP	0	0	0.4	0.22	0.5	0	0.35

We calculate the alternative priority weights by multiplying the weights of sub attributes with alternatives' values for sub attributes.

Table 5 Final Weights of Alternatives

	S	F	C	SL	Alternative Priority Weight
Weight	0.72	0	0	0.28	
Alternatives					
SD	0.65	0.84	1	0.65	0.65
PP	0.35	0.16	0	0.35	0.35

According to this result, SD which has the highest value with 65% priority weights is the software platform.

5. Conclusion

Both at a work life and at our personal life, mostly time, we are obliged to make a decision about the subject. The original reason of states when many elements are closed with each other and occasionally we tell that the time does not bundle up from a time inside is the difficulty to give a decision. For this we momently need systematic and MCDM. Nowadays many studying are made many about decision-making method, moreover software are developed.

A field where decision making methods are applied is selection of software application platform in the case study, Fuzzy AHP was used for selecting of software application platform will be developed for application of purchasing department. A survey is made in Company to establish importance weights (fuzzy preference numbers) that are necessary for selecting of best card technology. The survey was made with three people. SD with another high according to two card technologies rate has been selected.

Further research may be the application of Axiomatic Design to the smart card selection problem. The results obtained can be compared with the one of this paper.

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