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# FUZZY AHP-TOPSIS TWO STAGES METHODOLOGY FOR ERP SOFTWARE SELECTION: AN APPLICATION IN PASSENGER TRANSPORT SECTOR

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**ABSTRACT**
*Transportation that comes into existence from vital activities is natural necessity. The increased competition and the idea of arriving to destination rapidly with a minimum lost revealed the alternative transportation systems. In many stages of the transportation system, decision making tools may be used to get increased benefit. Also innovative technologies like ERP software are important to manage transportation systems effectively.*
*In this study, the most effective ERP software is selected for a firm that services at urban passenger transport sector using two-stage fuzzy decision making technique. In the first stage, after the lack of the software application is determined, the decision of developing the new software by software development department in firm or buying a package program is given. In the second stage, if developing of the new software in firm is selected, the programming language is determined to develop the most effective ERP software application platform using fuzzy decision making technique. On the contrary, if buying a package program is chosen, the most effective package program is selected by using fuzzy decision making techniques.*
**Keywords:** Passenger Transport, Fuzzy Multi criteria decision making, ERP Software Selection, Fuzzy AHP-TOPSIS

## 1. INTRODUCTION

When the decision making literature is considered about software selection, it is seen that many techniques are combined for a numerous application areas. Tolga and Kahraman (2009) have used fuzzy AHP to select the most appropriate software development projects. Gorener(2011) has made a decision for the optimal ERP using VIKOR method under criteria' weights given by ANP model. Wei et.al.(2005) have presented a comprehensive framework for selecting a suitable ERP system. Jadhav and Sonar(2011) have described generic methodology for software selection. Mulebeke and Zheng (2006) have aimed to introduce a methodology, the analytical network process as a multiattribute strategic decision making approach to help in the selection of appropriate software to suit the product development process of a particular product. Yazgan et.al.(2009) have used an ANN model has been designed and trained with using ANP results in order to calculate ERP software priority. And they have represented the ANN model had been come suitable for using in the selection of ERP for another new decision.
The Software selection is very important to develop firms' efficiencies. Because of this the software selection problems and ERP selection problems have been analyzed. We have not found the software selection problems especially ERP selection problems about urban passenger transport sector.

## 2. SOLUTION APPROACH

### 2.1. Fuzzy AHP

In this study, Chang's (1996) extent analysis method is preferred, since the steps of this approach are relatively easier than the other fuzzy-AHP approaches and similar to the crisp AHP. For the details of this method refer to Tuzkaya (2009).

### 2.2. Fuzzy TOPSIS

The explanation and mathematically calculation steps of the TOPSIS to the fuzzy environment are summarized below. This method is very suitable for solving the group decision-making problem under fuzzy environment. In this paper the algorithm is developed by Chen(200) will be used.
A fuzzy multi criteria group decision-making problem which can be concisely expressed in matrix format as

$$\widetilde{D} = \begin{bmatrix} \widetilde{x}_{11} & \widetilde{x}_{12} \cdots & \widetilde{x}_{1n} \\ \widetilde{x}_{21} & \widetilde{x}_{22} \cdots & \widetilde{x}_{2n} \\ . & . & . \\ \widetilde{x}_{m1} & \widetilde{x}_{m2} \cdots & \widetilde{x}_{mn} \end{bmatrix}, \quad \widetilde{w} = \left[\widetilde{w}_1, \widetilde{w}_2, ..., \widetilde{w}_n\right] \tag{1}$$

where $\widetilde{x}_{ij}, \forall_{ij}$ and $\widetilde{x}_{ij}, j = 1,2,...,n$ are linguistic variables. These linguistic variables can be described by triangular fuzzy numbers, $\widetilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ and $\widetilde{w}_j = (w_{j1}, w_{j2}, w_{j3})$

we can obtain the normalized fuzzy decision matrix denoted by $\widetilde{R}$

$$\widetilde{R} = \left[\widetilde{r}_{ij}\right]_{mxn} \tag{2}$$

where B and C are the set of benefit criteria and cost criteria, respectively, and

$$\widetilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right), \quad j \in B; \quad ve \quad \widetilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right), \quad j \in C \tag{3}$$

$$c_j^* = \max_i c_{ij} \quad if \quad j \in B; \quad c_j^* = \min_i a_{ij} \quad if \quad j \in C;$$

Considering the different importance of each criterion, we can construct the weighted normalized fuzzy decision matrix as

$$\widetilde{V} = \left[\widetilde{v}_{ij}\right]_{mxn}, \quad i = 1,2,...,m, \quad j = 1,2,...,n \tag{4}$$

where $\widetilde{v}_{ij} = \widetilde{r}_{ij}(.)\widetilde{w}_j$. Then, we can define the fuzzy positive-ideal solution $(FPIS, A^*)$ and fuzzy negative-ideal solution $(FPIS, A^-)$ as $A^* = (\widetilde{v}_1^*, \widetilde{v}_2^*, .., \widetilde{v}_n^*)$, $A^- = (\widetilde{v}_1^-, \widetilde{v}_2^-, .., \widetilde{v}_n^-)$, where $\widetilde{v}_j^* = (1,1,1)$ and $\widetilde{v}_j^- = (0,0,0), j = 1,2,...,n$. The distance of each alternative from A*and A− can be currently calculated as

$$d_i^* = \sum_{j=1}^{n} d(\widetilde{v}_{ij}, \widetilde{v}_j^*), \quad i = 1,2,...,m \quad d_i^- = \sum_{j=1}^{n} d(\widetilde{v}_{ij}, \widetilde{v}_j^-), \quad i = 1,2,...,m \tag{5}$$

The closeness coeficient of each alternative is calculated as

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-}, \quad i = 1,2,...,m \tag{6}$$

According to the closeness coefficient, the ranking order of all alternatives can be determined.

## 3. CASE STUDY

In this study we propose a decision making model to select the most appropriate software for an urban transportation firm that needs an new software application which must include online process following, purchasing processes, reporting services etc.

The case study has two steps. At first step, the most appropriate software technology selection will be made between developing a new software application and using a packet programming using Fuzzy AHP. If the packet programming is selected, at second step we will select the most appropriate packet programming between three alternatives using Fuzzy TOPSIS.

There are four main criteria and sixteen sub-criteria in our model and they are as follows:

1. *Software Performance and Technical Infrastructure (SPI):* Software Security and Software Reliability ,Software operating speed, software development time, web based application, customization and deployment time,advanced reporting services, adaptation with current operating system, hardware and database
2. *Cost:* Software development cost , Maintenance cost
3. *Flexibility:* compatibility with innovation(research and development) , adequacy of answering to customer requests , user-friendly interface, International flexibility (Language , currency unit legislation)
4. *Service Level:* Velocity of support after sale, Online Help After Sale

Importance weights of criteria and sub criteria are calculated by using Fuzzy AHP. Pairwase comparisons of alternatives are made.

*Table 1. The weights of sub-criteria*

| | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{14}$ | $C_{15}$ | $C_{16}$ | $C_{17}$ | $C_{18}$ | Priority weights of alternatives |
|---|---|---|---|---|---|---|---|---|---|
| **Weights** | 0,35 | 0,01 | 0,07 | 0,15 | 0,21 | 0,1 | 0,06 | 0,04 | |
| **Alternatives** | | | | | | | | | |
| **SD** | 0,5 | 1 | 1 | 0 | 0 | 1 | 0,5 | 0,5 | 0,42 |
| **PP** | 0,5 | 0 | 0 | 1 | 1 | 0 | 0,5 | 0,5 | 0,58 |

According to results (table) , PP which has the highest value with %53 priority heaviness is the software platform.

*Table 2. The weights of criteria*

| | $C_1$ | $C_2$ | $C_3$ | $C_4$ | Priority weights of alternatives |
|---|---|---|---|---|---|
| **Weights** | 0,41 | 0,05 | 0,22 | 0,32 | |
| **Alternatives** | | | | | |
| **SD** | 0,42 | 0,5 | 0,51 | 0,5 | 0,47 |
| **PP** | 0,58 | 0,5 | 0,49 | 0,5 | 0,53 |

After we have determined Packet Programming is the most appropriate alternative by fuzzy AHP, we applied Fuzzy TOPSIS to select the most appropriate Packet Programming.

There are 27 criteria to select the packet programming. You can find some criteria and their weights below.

*Table 3. The weights of criteria for Fuzzy Topsis Method*

| | | | | |
|---|---|---|---|---|
| Software Security and Software Reliability | H | 0,7 | 0,9 | 1 |
| Ease of software development | ML | 0,1 | 0,3 | 0,5 |
| Software operating speed | H | 0,7 | 0,9 | 1 |
| Development time | M | 0,3 | 0,5 | 0,7 |
| Advanced reporting service | ML | 0,1 | 0,3 | 0,5 |
| … | | | | |

You can see some linguistic ratings for alternatives with respect to criteria below.

*Table 4.The linguistic ratings for alternatives*

| | C1 | | | C2 | | | C3 | | | C4 | | | C5 | | | C6 | | | C7 | | | C8 | | | C9 | | | C10 | | | C11 | | | C12 | | | C13 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A1** | 8 | 9 | 10 | 0 | 1 | 3 | 9 | 10 | 10 | 0 | 1 | 3 | 5 | 7 | 9 | 7 | 9 | 10 | 3 | 5 | 7 | 3 | 5 | 7 | 5 | 7 | 9 | 0 | 1 | 3 | 0 | 1 | 3 | 0 | 1 | 3 | 5 | 7 | 9 |
| **A2** | 8 | 9 | 10 | 9 | 10 | 10 | 7 | 9 | 10 | 7 | 9 | 10 | 1 | 3 | 5 | 5 | 7 | 9 | 7 | 9 | 10 | 9 | 10 | 10 | 5 | 7 | 9 | 7 | 9 | 10 | 5 | 7 | 9 | 5 | 7 | 9 | 5 | 7 | 9 |
| **A3** | 8 | 9 | 10 | 5 | 7 | 9 | 9 | 10 | 10 | 3 | 5 | 7 | 7 | 9 | 10 | 3 | 5 | 7 | 5 | 7 | 9 | 7 | 9 | 10 | 7 | 9 | 10 | 3 | 5 | 7 | 3 | 5 | 7 | 3 | 5 | 7 | 1 | 3 | 5 |

After evalaution of alternatives for criteria, the importance weights of the criteria are calculated using Chen(2000)'s methodology. And the Weighted Normalized Fuzzy decision matrix is constructed. You can find some values of Weighted Normalized Fuzzy decision matrix

*Table5. Weighted normalized fuzzy decision matrix*

| | C1 | | | C2 | | | C3 | | | C4 | | | C5 | | | C6 | | | C7 | | | C8 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A1** | 0,56 | 0,81 | 1,00 | 0,00 | 0,03 | 0,15 | 0,63 | 0,90 | 1,00 | 0,00 | 0,05 | 0,21 | 0,35 | 0,63 | 0,90 | 0,21 | 0,45 | 0,70 | 0,03 | 0,15 | 0,35 | 0,09 | 0,25 | 0,49 |
| **A2** | 0,56 | 0,81 | 1,00 | 0,09 | 0,30 | 0,50 | 0,49 | 0,81 | 1,00 | 0,21 | 0,45 | 0,70 | 0,07 | 0,27 | 0,50 | 0,15 | 0,35 | 0,63 | 0,07 | 0,27 | 0,50 | 0,27 | 0,50 | 0,70 |
| **A3** | 0,56 | 0,81 | 1,00 | 0,05 | 0,21 | 0,45 | 0,63 | 0,90 | 1,00 | 0,09 | 0,25 | 0,49 | 0,49 | 0,81 | 1,00 | 0,09 | 0,25 | 0,49 | 0,05 | 0,21 | 0,45 | 0,21 | 0,45 | 0,70 |

*Table 6.* Coeficients of each alternative

| Distances | d* | d- | CCi |
|---|---|---|---|
| **A1** | 17,41 | 11,46 | 0,40 |
| **A2** | 15,14 | 14,06 | 0,48 |
| **A3** | 17,12 | 11,94 | 0,41 |

Because CC2> CC3> CC1, the preferred order of the alternatives A1, A2, A3 is: A2>A3>A1. That is, the best alternative A2

## 4. CONCLUSION

In this study, we have presented multi criteria decision making problems based on fuzzy sets to select the most effective ERP software for a firm that services at urban passenger transport sector. two-stage fuzzy decision making technique has been used for decision. In the first stage, the buying a package program have been selected using Fuzzy AHP. In the second stage the most effective package program A2 have been selected by using fuzzy TOPSIS

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