A Fuzzy MCDM Approach for Project Selection Criteria Prioritization in a Big-Four Company: Evidences from Turkey Consultancy Sector

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Abstract. Abstract. Project selection still remains as a debatable topic in Turkey as competitiveness between companies increases. There are too many factors to be taken into consideration since the process is very long and may be evaluated under uncertainty. Especially, main factors, such as financial, technical, social and risk factors, are not easily decided to take a project and consultancy companies need to be certain about a project's qualifications in order to minimize uncontrollable factor and maximize controllable factors. However, in many projects, the controllable factors cannot be easily decided, which mean the process does not clearly have a certainty. This paper aims to put forward an MCDM method to evaluate project selection qualifications in a Big-Four company located in Turkey, which leads the projects in Turkey and prioritize the project selection criteria under fuzziness in order to give a perspective about a project's main criteria and sub criteria and to focus on which qualifications should be focused.

Keywords: Project Selection, FAHP, MCDM, Big Four, Consultancy Sector

1 Introduction

Project selection is always a very challenging topic in every organization as it determines the management activities and performance. Especially, in developing countries, not only strategic decisions but also instinctive decisions of managers and workers in every level are very important to keep the company further. As technology keeps developing daily, technology is still being perceived as a very important competitiveness factor of a company [1]. Furthermore, different factors can be a key factor to evaluate a project. Firms generally select the most efficient projects, which do not only maximize the viable outcomes, such as profit and reputations, but also minimizes some negative factors such as environmental harms and negatively affected reputation [2]. In Turkey, the consultancy sector continues to grow as it is a developing country. Firms can do project selection in their own companies while they can choose to consult a consultancy firm, especially to Big Four companies. Big Four consultancy companies are seen as the most trusted and compatible companies in Turkey.

This study aims to find out the prioritization of the project selection criteria in a big four company with one of the multiple criteria decision-making methods: Fuzzy Analytic Hierarchy Process. After the introduction part, a literature review covers up MCDM and F-AHP. Then F-AHP is detailed in the methodology part and analysis shows the results that belongs to the selected big-four company. At the end, conclusion and future studies are mentioned.

2 Literature Review

In this study a multi criteria decision making model is used. To understand methodology in detail, both multiple criteria decision making (MCDM) and one of the MCDM method Fuzzy Analytic Hierarchy Process (F-AHP) literature is reviewed in the following titles briefly.

2.1 Multiple Criteria Decision Making (MCDM)

The objective of Multiple Criteria Decision Making (MCDM) is to select the best option between different alternatives, according to their attributes. MCDM increases efficiency so it leads to high quality decision results for important investment projects [3]. Many different methods are included in the MCDM and these methods are evaluating many and conflicting criteria for different alternatives. In words, ranking, classification, choice and description are the results for most preferred options in terms of MCDM [4].

Both qualitative and quantitative criteria can be considered while using MCDM methods. Not quantitative criteria but qualitative ones are subjective according to the experts and to be able to adapt them to MCDM methods, there are different ways to convert them to quantitative data. Expert designed units and scales are being used for this conversion [4]. There are different MCDM methods improved by the time. They have both advantages and disadvantages which are already mentioned in literature. Most common ones are: Analytic Hierarchy Process (AHP), Data Envelopment Analysis (DEA), Fuzzy Set Theory, ELECTRE and PROMETHEE [5].

2.2 Fuzzy Analytic Hierarchy Process (F-AHP)

Most common method is the traditional Analytic Hierarchy Process (AHP), which is firstly studied by Saaty for MCDM [6]. It is easier to understand in terms of mathematical calculations when compared with other MCDM methods. AHP is always criticized because of uncertainty between decision makers' thoughts and numbers. For fuzziness, fuzzy-AHP (F-AHP) is more suitable to conduct a hierarchical rating [7].

There are different calculations for fuzziness and the most common method is fuzzy AHP. Despite its disadvantages, it is beneficial to understand numerical side of the method easily so extent analysis is preferred for F-AHP. This analysis is steadier and get through with the uncertainty. Triangular fuzzy number is used for different criteria to compare them pairwise [8]. The details of F-AHP method steps are given in the methodology part.

3 Methodology

To make a decision or to understand a current problem may be complicated in some circumstances. With the help of fuzzy logic, solving engineering problems via using fuzzy sets becomes easier [9]. F-AHP considers the problems, which are uncertain and fuzzy. Decision-making can be expressed by natural language expressions, taking into account the importance of fuzzy AHP by decision makers [9].

Engineering and management are the top areas that are actively using F-AHP at their studies. Chang, studied triangular fuzzy numbers in context of a new extent F-AHP analysis [10]. The study done by Chang et al. evaluated supplier selection criteria with F-AHP [11]. Bozbura et al. used F-AHP for prioritization of human capital measurement indicators [12]. A governmental R&D project selection is done with F-AHP by Huang et al. [13]. Lee et al. studied F-AHP in Taiwan to evaluate IT departments of production sector [14]. Gumus studied evaluation of hazardous waste transportation by using F-AHP [15]. A waste management study done by Lung Hung, which evaluated municipal solid waste management with F-AHP [16].

For uncertain conditions, F-AHP method is very useful. Fuzzy set assigns membership between zero and one for grading [9]. Triangular fuzzy numbers are shown as the membership function in Figure 1.

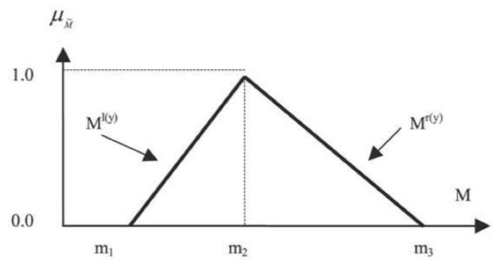

Fig. 1. Triangular fuzzy numbers [9].

Which is also expressed as the linear presentations interpreting as piecewise function on left and right sides, $\widetilde{M}$, in (1).

$$\mu(x|\widetilde{M}) = \begin{cases} 0, & x < m_1 \\ (x - m_1)/(m_2 - m_1), & m_1 \le x < m_2 \\ (m_3 - x)/(m_3 - m_2), & m_2 \le x < m_3 \\ 0, & x \ge m_3 \end{cases} \tag{1}$$

In that case, a fuzzy number can be expressed based on its left and right-side representation of the degrees of membership as given in (2) [17]

$$\widetilde{M} = \left(M^{l(y)}, M^{r(y)}\right) = (m_1 + (m_2 - m_1)y, m_3 + (m_2 - m_3)y) \; where \; y \in [0,1] \tag{2}$$

and $l(y)$ and $r(y)$ are denoted by the left side and right representation of the fuzzy number respectively.

The steps of fuzzy AHP can be explained as [13],

Step 1: Construct a scale which indicates the relative strength of each criteria and alternatives of which Chang-Huang et al. explained that triangular fuzzy numbers should be assigned by the relative strength of each alternative and criterion located in the same hierarchy.

Step 2: Compute the fuzzy judgement matrix where K criteria, $C_1, C_2, \dots C_k$ with a fuzzy judgment matrix, which can be interpreted as $\widetilde{A_k}$, and where the decision makers make a pairwise comparison in order to construct the fuzzy judgment matrix $\tilde{E}$,

$$\widetilde{A_k} = \begin{pmatrix} 1 & \tilde{a}_{12} & \cdots & a_{\widetilde{1(n-1)}} & \widetilde{a_{1n}} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \tilde{a}_{n1} & \widetilde{a_{n2}} & \cdots & a_{\widetilde{n(n-1)}} & 1 \end{pmatrix} \tag{3}$$

Where $i = j, a_{ij} = 1$ and $e_{ij} = 1$,

$$\tilde{E} = \begin{pmatrix} 1 & \tilde{e}_{12} & \cdots & e_{\widetilde{1(n-1)}} & \widetilde{e_{1n}} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \tilde{e}_{n1} & \widetilde{e_{n2}} & \cdots & e_{\widetilde{n(n-1)}} & 1 \end{pmatrix} \tag{4}$$

$\tilde{A}_{kl} = \left[\tilde{a}_{ij}^{kl}\right]$ and $\tilde{E}_l = \left[\tilde{e}_{ij}^{l}\right]$, it follows that $\tilde{a}_{ij}^{l} = (\tilde{a}_{ij}^{kl} \Theta \dots . \Theta \tilde{a}_{ij}^{kn})^{1/n}$ and $\widetilde{e_{\iota\jmath}} = (\tilde{e}_{ij}^{1} \Theta \dots . \Theta \tilde{e}_{ij}^{n})^{1/n}$

Step 3: The fuzzy value with respect to the i^{th} object can be defined as $S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$, where, $\sum_{j=i}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right)$

Step 4: Find the degree of possibilities such that $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ can be defined as $V(M_2 \geq M_1) = sup_{y \geq x}\left[\min(\mu_{M_1}(x), \mu_{M_2}(x))\right]$.

Furthermore, we need to compare M_2 *and* M_1 values by $V(M_2 \geq M_1)$ *and* $V(M_1 \geq M_2)$.

Then, $d'(A_i) = minV(S_i \geq S_k)$.

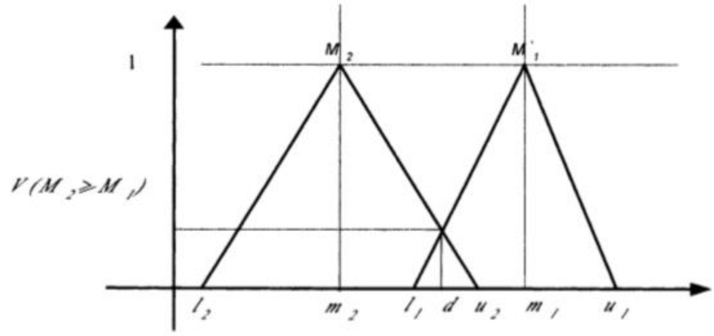

Fig. 2. The intersection of the values between M_1 and M_2 [9].

Step 5: Find normalized weights,
for $k = 1,2, \ldots n; k \neq i$, the weight vector can be found as $W' = (d'(A_1), d'(A_2), \ldots d'(A_n))^T$, and the normalized weights,

$W = (d(A_1), d(A_2), \ldots d(A_n))^T$, where W is crisp value.

4 Application

The given hierarchy shown in the Figure 1 has been formed by the experts working in a Consultancy Company in Turkey and the article studied by Jiang and Klein [18]. In order to avoid interdependency, the sub criteria have been grouped under criteria. The evaluations have been done by the experts. The criteria and sub criteria have been taken into consideration as follows;

A. Financial Criteria

A1. Net Present Value (NPV): NPV is a measurement in finance that measures the profitability of a project by inflows and outflows [19].

A2. Internal Rate of Return (IRR): an internal rate which is equal to 0 of the present worth of a cash flows [20]

A3. Benefit-Cost Ratio: A B/C Ratio can be defined as an indicator showing the relation between benefit and cost [21].

B. Social Criteria

B1. Reputation of the Company: Reputation of the company can be an indicator of a company's capability to take the project.

B2. Workers' Motivation: Workers' Motivation can be an effect to manage a project.

C. Risks Criteria

C1. Financial Risks: The project can create a high risk of money return and visibility.

C2. Technical Risk: The project cannot be applied and be technically wrong, which indicates

D. Technical Criteria

D1. Availability of Technology: A consultancy company should catch the techno logical developments.

D2. Infrastructure of Company: A company's infrastructure, for example Information Technology networks, should be sufficient to manage a project.

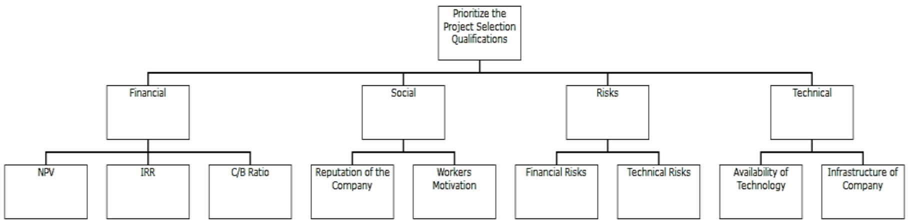

Fig. 3. The hierarchy of Project Selection Qualifications

After applying FAHP, the final ranking of criteria to evaluate project selection qualifications are shown in the Table 1.

Table 1. Final Ranking of Criteria to Evaluate Project Selection Criteria

Rank	Name	Weight
1	Financial	0.345
2	Social	0.297
4	Risks	0.074
3	Technical	0.284

Furthermore, under criteria, sub criteria evaluations are shown in Table 2,3,4 and 5 respectively.

Table 2. Final Ranking of Financial Sub Criteria to Evaluate Project Selection Qualifications

Rank	Name	Weight
1	NPV	0.443
2	IRR	0.302
3	C/B Ratio	0.254

Table 3. Final Ranking of Social Subcriteria to Evaluate Project Selection Qualifications

Rank	Name	Weight
2	Reputation of the Company	0.32
1	Workers Motivation	0.68

Table 4. Final Ranking of Risks Sub Criteria to Evaluate Project Selection Qualifications

Rank	Name	Weight
1	Financial Risks	0.71
2	Technical Risks	0.29

Table 5. Final Ranking of Technical Sub Criteria to Evaluate Project Selection Qualifications

Rank	Name	Weight
2	Availability of Technology	0.24
1	Infrastructure of Company	0.76

5 Conclusion

Consultancy sector is still growing in Turkey. It is important to choose a project via Big Four companies, which have a big trust between companies in Turkey. Project selection is always a very challenging topic to investigate. Even though there are many factors in deciding on qualifications and risks, only some factors are focused. Thus, the qualifications should be evaluated carefully and especially financial qualifications should be focused on, as Turkey is a developing country. The study has been done in a consultancy company which is called as a member of Big-Four by its experts. Expert opinions are used as inputs for F-AHP method in this analysis and different weights of different alternatives are the results of this study. It is concluded that in financial criteria, NPV is the most important one while in social criteria Workers' Motivation is the most important one. For further researches, the method can be changed and more factors can be taken into consideration.

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