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Assessment and Assortment of Projects Using Hybrid Mcdm Technique Under Fuzzy Environment Based on Economic Factors

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Abstract

Selection of project among a set of possible investment alternatives is a tough task that the decision maker (DM) has to face. For evaluation and selection of these projects, a set of six factors, i.e. Net present value, Rate of return, Benefit cost analysis, Payback period, investment size and Time until breakeven are considered. The objective of this work is to demonstrate the methodology of evaluating and selecting the best project by using hybrid multi criteria decision making technique (MCDM), i.e., fuzzy analytical hierarchy process (Fuzzy AHP) and fuzzy technique for order preference by similarity to ideal solution (Fuzzy TOPSIS). The criteria weights are calculated by using Fuzzy AHP whereas the global weights of all five projects

(Investment alternatives) are computed based on Fuzzy TOPSIS. Finally, from the findings of this work, the projects are ranked from most important to least important.

Keywords: Investment alternatives, Fuzzy Theory, Fuzzy AHP and Fuzzy TOPSIS

I. INTRODUCTION

Engineering economics is the specialized study of financial and economic aspects of the industrial decision making. The role of engineering economics is to assess the appropriateness of a given project, estimate its value, and justify it from an engineering point of view. The purpose of engineering economy deals with the methods used in evaluation of projects. The main objective is to determine the "best projects". There is a large literature dedicated to the project selection problem. It includes several approaches, which take into account various aspects of the problem. Strategic intent of the project, factors for project selection models has been thoroughly discussed by Meredith and mantle (2000).Danila (1999), Shpak and Zaporojan (1996) surveyed a number of the project selection methodologies and discussed several multi-criteria aspects of the problem. Mehrez and Sinuany stern (1983) formulated a project selection problem as a multi-criteria decision making (MCDM) problem and applied a utility function. Chu et al. (1996) demonstrated project selection process using fuzzy theory for ranking projects.

The project selection issues have been discussed in various management functions like in research and development (loch and Kavadias (2002)), environmental management (Eugene and Dey (2005)), and quality management (Hariharan et al. (2004)). Projects are unique in nature. Hence, each model has its own pros and cons for various applications. In our methodology first by using improved AHP with fuzzy set theory, the weight of each criterion is calculated. Then this article introduces a model that integrates improved fuzzy AHP with Fuzzy TOPSIS to support project selection decisions. The fuzzy AHP is the fuzzy extension of AHP to efficiently handle the fuzziness of the data involved in the decision making. It is easy to understand and it can effectively handle both qualitative and quantitative data in the multi-attribute decision making problems (MADM). In this approach triangular fuzzy numbers are used for the preferences of one criterion over another and then by using the extent analysis method, the synthetic extent value of the pairwise comparison is calculated. Other sections of the article are as follows: in the section II, criteria for the project selection have been mentioned. In section III, the fuzzy set theory explains. In section IV, we present our methodology. Finally, concluding remarks are provided in section V.

The common methods of comparing alternatives the main reason is today "Worth" more than tomorrow or after one year. The cost and benefits of an investment occur over an extended period of time rather than at the moment of purchase. Consequently, financial analyses studies much accommodate the future effects of current decisions. According to a concept that economists call the time value of money, all things being equal, it is better to have money now rather than later. The economic and financial analysis of the project is based on the comparison of the cash flow of all costs and benefits resulting from the projects activities. There are six common methods of comparing alternative investments: are Net present values, Rate of return, Benefit cost analysis, Payback period, investment size and Time until breakeven. Each of these is dependent on a selected interest rate or discount rate to adjust cash flows at different points in time (G. Lockett and M. Stratford (1987)).

The various evaluation criteria used in this paper are explained below:

A. **Net Present Value:** A net present value (NPV) is the present value of future cash inflows minus the cost including cost of investment calculated using an appropriate discounting method. Annual costs, future payments and gradients should be brought to the present. Converting all cash flows to present worth is often referred to as discounting. Therefore, the present value of a future cash flow represents the amount of money today, which, if invested at a particular interest rate, will grow to the amount of the future cash flow at that time in the future.

B. **Rate of Return:** The internal rate of return (ROR) method to analyze investment reflects and accounts for a major purchase or project allows you to consider the time value of money. Internal rate of return (IRR) is the discount rate which makes the net present value of revenue flows equal to zero or the investment equal to the present value of revenue flows. If more than one interest factor is involved, the solution is by trial and error.

C. **Benefit-Cost Analysis:** A benefit-cost analysis is a systematic evaluation of the economic advantages (Benefits) and disadvantages (Costs) of a set of investment alternatives. Benefit-cost (B/C) analysis is a method of comparison, in which the consequences of an investment are evaluated in monetary terms and divided into the separate categories of annual equivalents or present worth for comparison.

D. **Payback Period:** Probably the simplest form of financial analysis is the payback period analysis, which simply takes the capital cost of the investment and compares that value to the net annual revenues that investment would generate. Since this method ignores the time value of money and cash flows after the payback period, it can provide only a partial picture of whether the investment is worthwhile. The payback period represent the amount of time that it takes for a capital budgeting project to recover its initial cost.

E. **Investment Size:** The investment amount was briefly discussed in the valuation of money invested to startup the business. However, another aspect needs to be fully understood when raising money in a competitive environment with large VC funds. This is that the pre-money valuation goes up with the amount of money raised if all other things are held constant. This is especially important when considering large VC funds as they have a lot of money to put to work.

F. Time until breakeven: Your break-even point is the point at which your business is producing enough revenue each month to cover all your fixed and variable costs. Calculating the break-even point will give you an excellent idea of the costs involved in your business and the level of sales you will need to generate to cover your costs, which in turn will affect your overall business strategy.

Methodology

Structure the Decision Hierarchy

In this paper, five different projects: project 1, project 2, project 3, project 4 and project 5 are considered. For evaluation and selection of these projects, six set of factors: (Net present value, Rate of return, Benefit cost analysis, Payback period, investment size and Time until breakeven) are considered. Figure 1 demonstrates the hierarchical structure of the model representing the number of levels involved in the problem. Level 1, level 2 and level 3 indicate the overall objective of the problem, the set of criteria used, and the decision alternatives respectively.

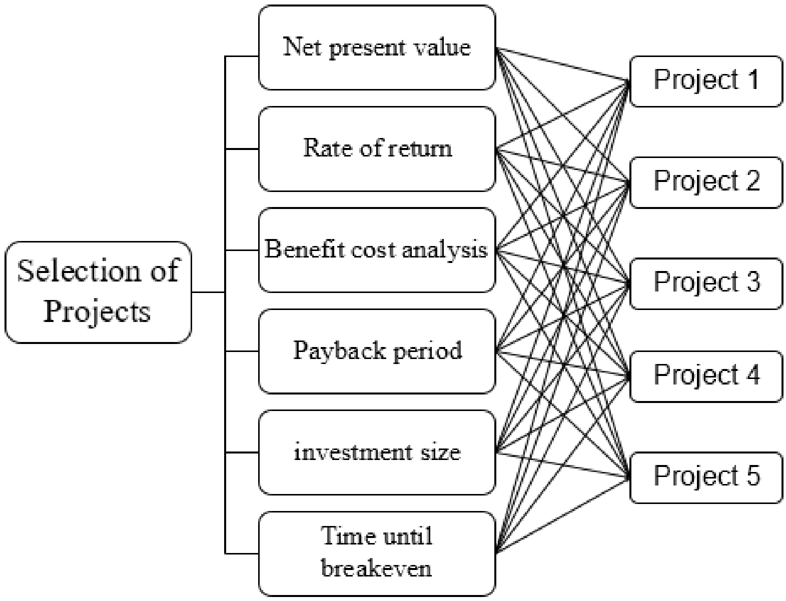

Fig 1. Overview of project selection

In general, the decision of project selection should include the reality of the multiple objectives of both the firm and its managers. Without the use of any common measurement system, it is very difficult for direct comparison of different projects. The consideration of project risks, technical risks, cost, time, and market risks are said to be more important while evaluating multiple projects. The capacity of the manufacturing firm should be sufficient enough to simulate various internal and external situations of a project and to optimize the decision of project selection.

Fuzzy AHP Methodology

Step 1. Construction of fuzzy pair-wise comparison matrix:

The fuzzy judgement matrix $A=\left\{a_{ij}\right\}$ of n criteria or Alternatives using pair-wise comparison is made by the use of TFNs as follows:

$$A=\begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ a_{21} & 1 & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & 1 \end{bmatrix}$$ Where a_{ij} is a Fuzzy Triangular Number

Step 2. Compute the value of Fuzzy Synthetic Extent

Based on the aggregated pair-wise comparison matrix, $A = \{a_{ij}\}$, the value of fuzzy synthetic extent S w.r.t the i_{th} criterion is calculated as follows

$$S_i = \sum_{j=1}^{n} a_{ij} \otimes [\sum_{i=1}^{n} \sum_{j=1}^{m} a_{ij}]^{-1}$$

Where

$$\sum_{j=1}^{m} a_{ij} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \text{ And } \sum_{i=1}^{n} \sum_{j=1}^{m} a_{ij} = \left(\sum_{i=1}^{n} l_j, \sum_{i=1}^{n} m_j, \sum_{i=1}^{n} u_j \right)$$

Step 3. Approximation of fuzzy priorities

On the basis of fuzzy synthetic extent values, the non-fuzzy values representing the relative preferences or weight of one criterion over others i.e. the degree of possibility are calculated using Chang's method as expressed below

$$V(S_i \geq S_j) = \begin{cases} 1, & if\ m_i \geq m_j \\ \dfrac{(u_i - l_j)}{(u_i - m_i) + (m_j - l_j)}, & if\ l_j \leq u_i \\ 0, & others \end{cases},$$

Where $i, j = 1, ..., n; j \neq i$

The degree of possibility for a TFN S_i to be greater than the number of **n** TFNs can be given by $V(S_i \geq S_1, S_2, S_3, ...S_k) = \min (S_i \geq S_1, S_i \geq S_2, ..., S_i \geq S_k) = w(S_i)$ where $k \neq i$. Each $w(S_i)$ value represents the relative preferences or weight, a non-fuzzy number, of one criterion over others.

Step 4. Determination of Normalized Weights

The normalized weights $W(S_i)$ will be formed in terms of a weights vector as follows:

$$W = (w(S_1), w(S_2), ... w(S_n))^T$$

2.3 Fuzzy TOPSIS Methodology

In the following section, some basic important definitions of fuzzy sets from Zimmermann (1991), Buckley (1985), Zadeh (1965), Kaufmann and Gupta (1991), Yang and Hung (2007) and Chen et al. (2006) are reviewed and summarized. It is often difficult for a DM to assign a precise performance rating to an alternative for the criteria under consideration. The merit of using a fuzzy approach is to assign the relative importance of criteria using fuzzy numbers instead of precise numbers. This subsection extends TOPSIS to the fuzzy environment.

Definition 1: Let $a = (l_1, m_1, u_1)$ and $\tilde{b} = (l_2, m_2, u_2)$ be two TFNs, then the vertex method is defined to calculate the distance between them, as equation:

$$d(a,\tilde{b}) = \sqrt{\frac{1}{3}\left[(l_1 - l_2)^2 + (m_1 - m_2)^2 + (u_1 - u_2)^2\right]}$$

Definition 2: Considering the different importance values of each criterion, the weighted normalized fuzzy-decision matrix is constructed as:

$$V = [\tilde{v}_{ij}]_{n \times J} \quad i = 1, 2, \ldots.., n, \quad j = 1, 2, \ldots, J$$

1. Numerical illustration

Our application is to relate to manufacturing sector the main aim is to select the best project among the available five alternatives. There are three decision makers in the committee. Then evaluation criteria are determined as Net present value (C1), Rate of return (C2),, Benefit cost analysis (C3),, Payback period (C4),, investment size (C5) and Time until breakeven (C6).

3.1 Application with FUZZY AHP

In this section fuzzy AHP method is proposed for the determination of the weights of the evaluation criteria. Firstly three decision makers evaluated and prepared the pair wise comparison matrix using the linguistic variables. Finally the weights of the criteria are determined in the following manner explained below.

Table 1. Fuzzy Comparison Measures

Linguistic Terms	Triangular Fuzzy Numbers	Reciprocals
Equally Important	(1,1,1)	(1,1,1)
Extremely Low Important	(1,1,2)	(1/2,1,1)
Very Low Important	(1,2,3)	(1/3,1/2,1)
Low Important	(2,3,4)	(1/4,1/3,1/2)
Moderately Low Important	(3,4,5)	(1/5,1/4,1/3)
Important	(4,5,6)	(1/6,1/5,1/4)
Moderately High Important	(5,6,7)	(1/7,1/6,1/5)
High Important	(6,7,8)	(1/8,1/7,1/6)
Very High Important	(7,8,9)	(1/9,1/8,1/7)
Extremely High Important	(8,9,9)	(1/9,1/9,1/8)

Table 2 Inter-Criteria Comparison Matrix

Criteria No	C1	C2	C3	C4	C5	C6
C1	(1,1,1)	(1/8,1/7,1/6)	(1/7,1/6,1/5)	(1,1,2)	(2,3,4)	(1,2,3)
C2	(6,7,8)	(1,1,1)	(1/5,1/4,1/3)	(2,3,4)	(1/8,1/7,1/6)	(1/3,1/2,1)
C3	(5,6,7)	(3,4,5)	(1,1,1)	(1/6,1/5,1/4)	(1,2,3)	(1/5,1/4,1/3)
C4	(1/2,1,1)	(1/4,1/3,1/2)	(4,5,6)	(1,1,1)	(5,6,7)	(1,1,2)
C5	(1/4,1/3,1/2)	(6,7,8)	(1/3,1/2,1)	(1/7,1/6,1/5)	(1,1,1)	(1,2,3)
C6	(1/3,1/2,1)	(1,2,3)	(3,4,5)	(1/2,1,1)	(1/3,1/2,1)	(1,1,1)

So, the Priority Weights W' are obtained from minimum values of d' of criteria. After the normalization of these values, the Priority Weight represent to main goal is calculated as (0.0845, 0.1827, 0.2145, 0.2302, 0.1646, and 0.1235). These weights have been used for further evaluation of ranking the projects using FUZZY TOPSIS

3.2 Application of Fuzzy TOPSIS

This this section Fuzzy TOPSIS method is proposed to select the best alternative. Firstly, three decision makers evaluated the importance of criteria by using the linguistic variables. Three decision makers use these linguistic variables to evaluate the ratings of the alternatives with respect to each criterion. The fuzzy decision matrix is as shown in Table 3.

Table 3 Fuzzy Decision Matrix and fuzzy weights

Criteria	C1	C2	C3	C4	C5	C6
	0.0845	**0.1827**	**0.2145**	**0.2302**	**0.1646**	**0.1235**
P1	(5.67, 6.67, 7.67)	(4, 5, 6)	(2,3,4)	(5, 6, 7)	(3, 4, 5)	(3.67,4.67, 5.67)
P2	(5, 6, 7)	(5, 6, 7)	(3, 4, 5)	(7, 8, 8.67)	(4.33, 5.33, 6.33)	(4.33,5.33,6.33)
P3	(4.33,5.33,6.33)	(3, 4, 5)	(3.67,4.67,5.67)	(5.33,6.33,7.33,)	(5.33,6.33,7.33)	(4.67,5.67,6.67)
P4	(5.33,6.33,7.33)	(4.67,5.67,6.67)	(4,5,6)	(6,7,8)	(4.33,5.33,6.33)	(4,5,6)
P5	(6,7,8)	(3.67,4.67,5.67)	(2.33,3.33,4.33)	(6.67,7.67,8.67)	(5,6,7)	(3,4,5)

Table 4 Weighted normalized fuzzy decision matrix

Criteria	C1	C2	C3	C4	C5	C6
P1	(0.4791, 0.5636, 0.6481)	(0.7308, 0.9135 , 1.0962)	(0.4290,0.6435,0.8580)	(1.1510,1.3812,1.6114)	(0.4938,0.6584,0.8230)	(0.4532, 0.5767, 0.7002)
P2	(0.4225, 0.5070 , 0.5915)	(0.9135, 1.0962 , 1.2789)	(0.6435,0.8580,1.0725)	(1.6114,1.8416,1.9958)	(0.7127,0.8773,1.1419)	(0.5348,0.6583,0.7818)
P3	(0.3659,0.4504,0.5349)	(0.5481,0.7308,0.9135)	(0.7872,1.0017,1.2162)	(1.2270,1.4572,1.6874)	(0.8773,1.0419,1.2065)	(0.5767,0.7002,0.8237)
P4	(0.4504,0.5349,0.6194)	(0.8532,1.0359,1.2186)	(0.8580,1.0725,1.2870)	(1.3812,1.6114,1.8416)	(0.7127,0.8773,1.0419)	(0.4940,0.6175,0.7410)
P5	(0.5070,0.5915,0.6760)	(0.6705,0.8532,1.0359)	(0.4998,0.7143,0.9288)	(1.5354,1.7656,1.9958)	(0.8230,0.9876,1.1522)	(0.3705,0.4940,0.6175)

Table 5 Distance of each alternative from FPIS (fuzzy positive ideal solution)

	C1	C2	C3	C4	C5	C6	D^*
P1	0.9374	0.8987	0.9287	0.8468	0.9270	0.0651	4.6036
P2	0.9437	0.8784	0.9049	0.7984	0.9026	0.0740	4.5020
P3	0.9500	0.9189	0.8889	0.8384	0.8844	0.0786	4.5592
P4	0.9406	0.8851	0.8810	0.8212	0.9026	0.0695	4.5001
P5	0.9343	0.9054	0.9208	0.8041	0.8904	0.0560	4.5110

Table 6 Distance of each alternative from FNIS (fuzzy negative ideal solution) and Relative closeness values

	C1	C2	C3	C4	C5	C6	D-	CC_j	Ranking
P1	0.0631	0.1028	0.0741	0.1549	0.0747	0.9360	1.4056	0.2339	5
P2	0.0569	0.1229	0.0973	0.2026	0.0986	0.9269	1.5052	0.2506	2
P3	0.0506	0.0829	0.1130	0.1632	0.1167	0.9223	1.4487	0.2411	4
P4	0.0599	0.1163	0.1207	0.1803	0.0986	0.9315	1.5073	0.2509	1
P5	0.0662	0.0962	0.0817	0.1973	0.1107	0.9452	1.4973	0.2492	3

The weighted normalized fuzzy decision matrix is formed as shown in Table 4. We define fuzzy positive ideal solution (FPIS, A*) and a fuzzy negative ideal solution (FNIS, A^-) as $\tilde{v}_i^* = (1,1,1)$ *and* $\tilde{v}_i^- = (0,0,0)$ for benefit criterion and

$\tilde{v}_i^* = (0,0,0)$ *and* $\tilde{v}_i^- = (1,1,1)$ for cost criteria. The distances of each alternative from FPIS and FNIS with respective each criterion are shown in Table 5 and Table 6. D^* and D^- are shown in Table 5 and Table 6 then closeness coefficient of five alternatives are calculated and tabulated in Table 6. According to the closeness coefficient of five alternatives, the ranking order of five alternatives is determined as P4>P2>P5>P3>P5. The fourth alternative is determined as a most appropriate alternative. In other words the fourth alternative is closer to the FPIS and farther from the FNIS.

II. CONCLUSION

It's found that the application results satisfactory and decided to select the best alternative Projects. Under environment using Fuzzy AHP and Fuzzy TOPSIS methods are appropriate for evaluation and selection of projects. Here the project 4 is first priory and project 1 is least priory according to the criteria chosen for evaluation and selection of projects under fuzzy environment.

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