Project Selection Problem by Combination of Shannon Entropy and MCDM Techniques

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Abstract**—** The Importance of selecting suitable projects among the proposed projects is one of the important decisions and strategies in almost every companies especially the project-based organizations. This paper focuses on developing a model based on Shannon's Entropy and MCDM techniques for solving the project portfolio selection problem, for this purpose, first, the criteria that are suitable for project selection problem, are identified, then, Shannon's Entropy is performed for determining the weights of criteria and fuzzy topsis for ranking projects.

Keywords**—**Project selection; Shannon's Entropy; fuzzy topsis

I. Introduction

THE goal of the project selection process is to analyze projects and to approve or reject project proposals based on established criteria, following a set of structured steps. Project selection is the basis of project management system. Selecting the suitable project is always an important task for decision makers.

In recent years, many multi criteria decision making (MCDM) techniques have been developed for dealing with project selection problems. Amiri, employed MCDM methods based on AHP and fuzzy TOPSIS for project selection in oil-field development [1]. Badri et al, used a goal programming model for information system project selection [2]. Carazo et al proposed a comprehensive model for the portfolio of several objectives [3]. Gabriel et al, prepared a multi objective integer optimization model with distributions of costs probability [4]. Ghasemzadeh, et al, applied a 0-1 goal programming for project selection problem [5]. Mahmoodzadeh et al, applied fuzzy AHP and TOPSIS method for project selection problem [10]. Mohanty, used The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) approach, as an MCDM technique, for the project selection problem [11]. Mohanty also, proposed a fuzzy analytical network process (ANP) - based approach to project selection [12]. Pangsri, applied MCDM techniques in project selection problem, it was based on AHP and TOPSIS methods [13]. There are various methods on project selection in the different fields. Salehi, presented Vikor and AHP methods for project selection problem [16]. Singh proposed a Resource Constrained Multi-Project Scheduling with Priority Rules & Analytic Hierarchy Process for evaluating projects [17]. Also other researches such as ([4], [7], [6], [8], [9], [14], [18] and [19]) used mathematical programming approach for modeling project selection problem.

This paper focuses on introducing a model based on Shannon's Entropy and MCDM techniques (Fuzzy topsis) for solving the project portfolio selection problem. For this purpose, the rest of the paper is organized as follows: Section 2 states the criteria for project selection problem. Sections 3 and 4 discuss Shannon's Entropy and fuzzy topsis techniques to weight criteria. Finally sections 4 and 5 state the results of presented model combined of Shannon entropy and Fuzzy topsis in a numerical example.

II. Criteria of Project Selection Problem

In this section, the criteria related to project selection problem are introduced. For criteria identification, some books, thesis, papers and also libraries are reviewed. These criteria are shown in table1.

TABLE1
IDENTIFICATED CRITERIA IN PROJECT PORTFOLIO SELECTION

General criteria
Project Selection Criteria
NPV(Net Present Value)
Strategic Plan
Projects constraint
Competency and Skills of managers and staffs
Organizational experience
Risks of projects
Acquire technology
Time delays
Competitive advantage
Stability of rules and performance standards
Organizations image
Executive familiar with the project team
Staff satisfaction
Competences and capabilities of staffing company
Marketing plan
Customer preferences
Human resources

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climate changes
Availability of materials, machinery and other work essentials
Work experience with an employer or other elements of the project in previous projects
Costs
Anticipated cash flow interaction of the project with existing projects
The availability of time and human resources
revenue growth of Company
Price Fluctuations
The prepayment
The size of the organization and the need for new project
basic systems for Implementation of the projects
IRR(Investment Return Rate)

III. SHANNON'S ENTROPY

Entropy algorithm is one of the useful tools for acquiring weights of criteria. Consider Pij in decision matrix for alternatives' evaluation. There are n alternatives and K criteria in decision matrix. The probability of each element is distributed based on its probability function. The element of this matrix for jth criterion is as below:

$$P_{ij} = \frac{f_j(a_i)}{\sum_{i=۱}^{n} f_j(a_i)}$$

$$E_j = -M \sum_{i=۱}^{n} P_{ij} \, lnP_{ij}$$

M as a constant is calculated based on the following equation:

$$M = \frac{۱}{\ln(n)}$$

And E_j is a value between 0 and 1.

Next step is to calculate deviation degree (di) which says that to what extent jth criterion has useful information for decision maker. If there is little difference between one criterion values, it means that alternatives are indifferent according to this criterion so its effect in decision making should be diminished. Deviation degree is obtained as below:

$$d_i = ۱ - E_i \qquad j$$

The final step in Shannon entropy is to obtain weights based on following equation:

$$w_j = \frac{d_j}{\sum_{j=۱}^{k} d_j}$$

IV. FUZZY TOPSIS

Having calculated the weight of each criterion by using Shannon entropy, the next step is to adopt the fuzzy TOPSIS method as the ranking method for ranking projects.

The fuzzy TOPSIS method consists of following steps (Chen 2000):

Step 1: Construct the fuzzy decision matrix $\widetilde{D}$ for m criteria and n alternatives. $\tilde{X}_{ii} = (a_{ij}, b_{ij}, c_{ij})$ represents the transformed TFNs from linguistic terms.

$\widetilde{D}$ is represented as follows:

$$\widetilde{D} = \begin{matrix} \tilde{X}_{۱۱} & \cdots & \tilde{X}_{۱n} \\ \vdots & \ddots & \vdots \\ \tilde{X}_{m۱} & \cdots & \tilde{X}_{mn} \end{matrix}$$

Step 2: Calculate the normalized fuzzy decision matrix $\widetilde{R}$ as follows:

$$\tilde{R} = [\tilde{r}_{ij}]_{m*n}$$

The normalized is calculated as:

$$\tilde{r}_{ij} = [\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}]$$

$$c_j^* = \max c_{ij} \quad i = ۱,۲, \dots, m \quad j = ۱,۲, \dots, n$$

To avoid the effect of outliers, TOPSIS needs to normalize the decision matrix.

Step 3: Calculate the weighted normalized decision matrix $\widetilde{V}$: In this study, the weights are obtained from previous ANP approach. The weighted normalized value $\tilde{V}_{ij}$ is calculated as follows:

$$\tilde{V}_{ij} = w_i r_{ij} \quad i = ۱,۲, \dots, m \quad j = ۱,۲, \dots, n$$

$$\tilde{V} = [\tilde{V}_{ij}]_{min}$$

Where W_i is the weight of the ith criterion and

$$\sum_{i=۱}^{m} W_i = ۱$$

Step 4: Determine the fuzzy positive ideal solution $A^*$and fuzzy negative ideal solution A^-.

$$A^* = (\tilde{v}_۱^*, \tilde{v}_۲^*, \dots, \tilde{v}_n^*)$$

$$A^- = (\tilde{v}_۱^-, \tilde{v}_۲^-, \dots, \tilde{v}_n^-)$$

$$v_j^* = (۱,۱,۱) \; and \; v_j^- = (۰,۰,۰)$$

Step 5: Calculate the distance of each alternative using $A^* \; and \; A^-$as follows:

$$D_j^* = \sum_{i=۱}^{m} d(\tilde{v}_{ij}, \tilde{v}_i^*) \quad j = ۱,۲, \dots, n$$

$$D_j^- = \sum_{i=۱}^{m} d(\tilde{v}_{ij}, \tilde{v}_i^-) \quad j = ۱,۲, \dots, n$$

Where

$$d(\tilde{A}, \tilde{B}) = \sqrt{۱/۳[(a^۱ - b^۱)^۲ + (a^۲ - b^۲)^۲ + (a^۳ - b^۳)^۲]}$$

Step 6: Calculate the relative closeness to the positive ideal solution: The relative closeness of the alternative A_i with respect to $A^*$is defined as:

$$RC_j^* = \frac{D_j^-}{D_j^* + D_j^-} \quad i = ١,٢, \ldots, n$$

Step 7: Rank the preference order: The index values of RC_j^* lie between 0 and 1. The larger index value means closer to a positive ideal solution for alternatives.

V. The Criteria Weighting

In the first stage, candidate projects and the criteria are determined.

TABLE III.
IDENTIFIED CRITERIA IN THE PROPOSED MODEL

Criterion Index	Criterion
C1	Price Fluctuations
C2	NPV(Net Present Value)
C3	Risks of projects
C4	Time delays
C5	Organizational experience
C6	Executive familiar with the project team
C7	Availability of materials, machinery and other work essentials
C8	Costs
C9	The availability of time and human resources
C10	Marketing plan
C11	Competitive advantage
C12	Acquire technology
C13	Strategic Plan

Based on the information from five experts, the following results were obtained:

TABLE IV
EXPERT'S OPINIONS ABOUT CRITERIA

	N1	N2	N3	N4	N5
C1	2	3	4	4	3
C2	2	6	5	3	1
C3	3	4	3	2	6
C4	3	7	5	6	4
C5	3	4	2	1	1
C6	2	2	3	3	5
C7	4	5	5	8	5
C8	1	2	3	5	4
C9	3	2	5	4	3
C10	3	4	5	5	1
C11	6	7	5	4	2
C12	2	3	4	5	6
C13	1	4	5	6	3

As a result, regarding to Shannon's Entropy approach, the weights of the criteria are as follow:

TABLE IV
THE RESULTS OF SHANNON'S ENTROPY

Criterion Index	Weight
C1	0.027204
C2	0.149611
C3	0.064262
C4	0.038942
C5	0.134311
C6	0.059078
C7	0.027795
C8	0.11377
C9	0.042839
C10	0.099205
C11	0.067482
C12	0.061746
C13	0.113753

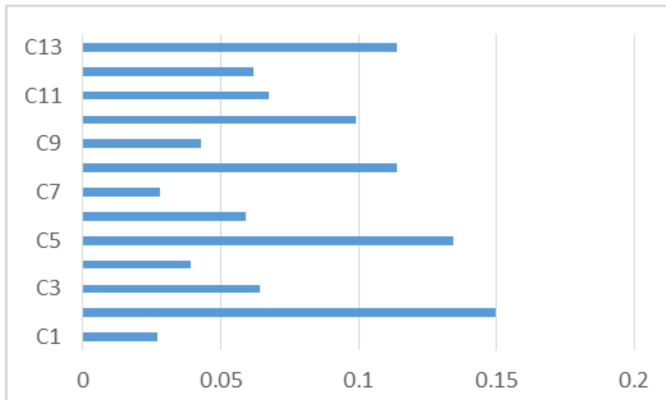

Fig. 1. Criteria weight

After calculating the weights of criteria, at the next step, the weights of projects should be determined. Using topsis technique, these weight are as what shown in table 5.

TABLE V
THE RESULTS OF FUZZY TOPSIS

Projects	D_j^*	D_j^-	RC_j^*
P1	0.649	0.950	0.594
P2	0.818	0.768	0.484
P3	0.691	0.880	0.560

Weights of projects show that the results of ranked projects. According to this table, among different projects, P1 is the best choice.

VI. Summary and Conclusion

One of the basic tasks for decision makers is related to project selection problem. Selection of a suitable project portfolio is an important decision that project-based organizations are encounter with. Selecting the right projects is always a difficult task for decision makers. This study proposes a model for the project selection problem with combination of MCDM and Shannon entropy techniques. For future researches, using combination of other MCDM techniques under fuzzy environment for dealing with project selection problem can be suggested.

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