MCDM Techniques and Knapsack Approach for Project Selection Problem: A Case Study

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***Abstract*—** The importance of selecting appropriate projects among the identified projects includes important decisions and strategies in almost every companies especially the project-based organizations in which the lack of planning and enough precision could have unpleasant influences on the organization.. This paper focuses on developing a model based on Knapsack approach and ANP methods for solving the project portfolio selection problem, consists of these basic stages: at first, the criteria and sub criteria to be used in the model are identified, then, ANP method is performed for determining the weights of the criteria and projects, at the end based on ANP results and Knapsack approach, by Knapsack approach which considers some constraints such as budget constraints the optimal projects would be selected.

Keywords*:* project selection, ANP, Knapsack approach

I. Introduction

PROJECT selection is one of the important issue in industrial engineering, governmental nonprofit and commercial organization. The goal of the project selection process is to analyze project viability and to approve or reject project proposals based on established criteria, following a set of structured steps and checkpoints.

In recent years, many multi criteria decision making (MCDM) methods have been developed for Project Selection problems. [12] used The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) approach, as an MCDM technique, for the project selection problem.[11] applied fuzzy AHP and TOPSIS method for project selection problem. [1] employed AHP and fuzzy TOPSIS methods for project selection in oil-field development. [17] presented Vikor and AHP methods for project selection problem. [18], proposed a methodology based on Hybrid algorithms for evaluating projects. [13] in other work, proposed a fuzzy analytical network process (ANP) - based approach to project selection.[14], applies MCDM techniques in project selection problem, it was based on AHP and TOPSIS methods. There are various methods on project selection in the different fields. The majority of accomplished works often yield complicated mathematical programming such as mixed integer or nonlinear programming. For example, [6] applied a 0-1 goal programming for project selection problem. [20] proposed a multi objective optimization model for project portfolio selection by considering efficiency of human resource. They considered efficiency of each project and economic goal as the objectives of their model. They implemented their proposed model on a real case in the field of e-commerce in Austria .[19] proposed a probabilistic integer programming for selecting R&D projects under uncertainty. The objective of this model is to maximize the rate of return for capital . [2] used a goal programming model for information system project selection. [3] introduced a comprehensive model for the portfolio of several objectives. [5] prepared a multi objective integer optimization model with distributions of costs probability, [4] used a hybrid grey rational analysis and non-dominated sorting Genetic algorithm for selection project portfolio. They first ranked the project by grey rational analysis which leaded to find optimal project portfolio. As they consider the risk for project selection, fuzzy environment is used to calculate risk of each project. Then risk and ranks used in a two objective zero-one programming model and solve it through non-dominated sorting Genetic algorithm for the final selection . and any other researches (e.g. , [7], [8], [5], [15], and [10].

This paper focuses on developing a model based on Knapsack approach and ANP methods for solving optimal project portfolio selection problem. To achieve this purpose, the rest of this paper is organized as follows: In section 2, some criteria of project selection that are more common in each field are introduced .Section 3 discusses the proposed model, that included two stages, In section4, for this purpose the developed methodology is executive in an Case Study.

II. Criteria of Project Selection Problem

In this section, at first the Criteria of Project selection are introduced. For identification of criteria, some books, thesis, papers and also libraries are used. The listed criteria are shown in table1.

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TABLE I
IDENTIFICATED CRITERIA IN PROJECT PORTFOLIO SELECTION

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
Organizations image
Marketing plan
Human resources
Costs
IRR(Investment Return Rate)

III. THE PROPOSED MODEL

The proposed model for the project selection problem, based on ANP and Knapsack approach, consists of 2 basic stages: at first, Weighting stage and selection stage. In weighting stage, at first criteria and sub criteria to be used in the model are identified, then, ANP method is performed for determining the weights of criteria, at the end based on ANP results and by Knapsack approach which considers some constraints such as budget constraints and time limitations , the optimal projects will be selected. Flowchart of the proposed model is shown in figure 1.

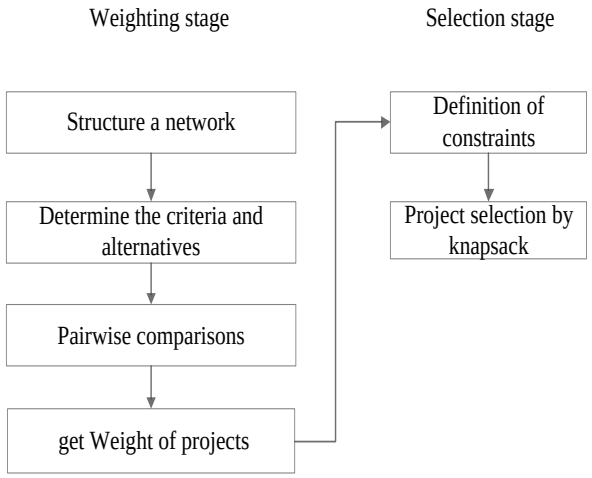

Fig1: The Proposed Model

3.1. ANP

ANP is one of the best MCDM techniques for evaluating and weighting criteria, As the ANP is a generalization of the AHP, we first review AHP in this section. AHP, developed by Saaty (1980), that was developed in order to quantify the importance of a set of criteria in a multi-criteria decision making problem. The process makes it possible to incorporate judgments on intangible qualitative criteria alongside tangible quantitative criteria (Badri, 2001) (Amiri, 2010).

A classical AHP can be constructed as follows. The goal, criteria, and alternatives form at least three levels of a linear hierarchy tree. After determining the overall goal and the criteria and alternatives for a particular decision, the pairwise comparison can be obtained. This pairwise comparison can be based on value choices from individuals involved in the decision-making and are often based on a 1-9 scale of importance (Saaty, 1996).

The ANP, which is a derivative of AHP ,has also been used in many applications multi-criteria decision-making (Saaty, 1996, Saaty, 2004) such as project selection (Habib et al., 2009). Both ANP and AHP utilize pairwise comparisons to determine weights of the criteria used in order to make a decision. These weights can then be used to determine which alternative or option is the most optimal based on criteria weights. Alternatively, the weights derived from the AHP process can also be applied to other multi-criteria decision models (Amiri, 2010). Unlike AHP, the ANP has the ability to allow the decision criteria to interact and for the criteria to be affected by the alternatives. Thereby, while ANP is more involved mathematically, it provides a broader, more realistic approach to multi-criteria decision-making.

the AHP and ANP , Both of them are based on a comparative judgment of the alternatives and criteria. Since ANP dismisses the hierarchical structure associated with AHP it allows criteria to interact with each other. After creating the local priority matrix for the criteria, which consists of deriving matrix. Although this supermatrix allows for influence of every element on every other element, if two clusters have no influence on one-another, then A_{ij} =0. While criteria can be grouped into clusters, a cluster could also contain only one criterion.

Unlike AHP, the ANP supermatrix allows for interdependence between all of the elements (criteria and alternatives).

3.2. Knapsack approach

The multidimensional 0–1 knapsack problem (MKP) is a special case of general linear 0–1 programs. Several names have been mentioned in the literature for the MKP: m-dimensional knapsack problem, multidimensional knapsack problem, multiknapsack problem, multiconstraint 0–1 knapsack problem, etc. In project selection with knapsack approach suppose that there are some projects each project has benefits, cost and duration for execution. because of budget constraints and time limitations, all the proposed projects cannot be done so organization can select the best projects considering resource constraints and planning horizon constraints to projects by using the appropriate way, thus gain more profits.

The proposed model in this study, find the optimal project portfolio among all proposed project in a project- based organization. For modeling this problem, we design knapsack approach. The formulation of proposed knapsack approach for project selection is as follow:

In the proposed model, the following indices and parameters are used:

P_i: Benefit of project i

V_i: Weight of project i(by a results of ANP)

d_i: Duration of project i

C_i: Cost of project i

T: Time horizon

Decision variables:

X_i: If project i selected 1, otherwise 0.

The problem formulation is as follows:

$$max \sum_{i=1}^{n} V_i X_i$$

St:

$$\sum_{i=1}^{n} C_i X_i \leq C \quad \textbf{(1)}$$

$$X_i \in \{0,1\} \quad \textbf{(2)}$$

The objective function is to maximize the total value of the selected project portfolio. Constraint (1) describes the budget constraints. Constraints (2) declare the decision variables.

IV. Case Study

4.1. Identification of criteria in in Proposed Model

For using Anp at first criteria have to be identified.in this case study by decision maker's opinion of this organization the criteria are as follow:

TABLE II
IDENTIFIED CRITERIA IN THE PROPOSED MODEL

Criteria	
Organizational factors	
C_1	Experiences in similar projects
C_2	Competency and skills of managers and staffs
C_3	Weakness and strengths
C_4	Managers policies
Executive factors	
C_5	Risk level of project
C_6	Acquired technology
C_7	Stakeholders
C_8	Project constraints
C_9	Organization 'S Strategic plan
Financial factors	
C_{10}	NPV
C_{11}	IRR
Market factors	
C_{12}	Inter to domestic market
C_{13}	Skills of rivals

4.2. Weights of criteria

In order to complete stage ranking of the proposed model, the Super Decision Software was utilized for the criteria network and the pairwise. The results of the Software are given in Table 3.

TABLE III
THE WEIGHTS OF CRITERIA

Criteria		Weight
C_1	Experiences in similar projects	0.300
C_2	Competency and skills of managers and staffs	0.223
C_3	Weakness and strengths	0.301
C_4	Managers policies	0.175
C_5	Risk level of project	0.132
C_6	Acquired technology	0.162
C_7	Stakeholders	0.174
C_8	Project constraints	0.244
C_9	Organization 'S Strategic plan	0.286
C_{10}	NPV	0.444
C_{11}	IRR	0.555
C_{12}	Inter to domestic market	0.671
C_{13}	Skills of rivals	0.328

4.3. Project selection by knapsack approach

In this stage, firstly we will discuss determining projects under the study (a project-based company). In the first stage, the following projects will be identified through interviewing the experts and collecting their views. The projects on which experts emphasized are as follow in table 4. (According to the confidential issues inside the company, the identified projects will be shown parametrical and we will skip giving the exact names of the projects according to the company's request.)

TABLE IV
IDENTIFIED PROJECTS LIST

projects	C_i	V_i
P1	1575600	0.218343
P5	1063530	0.2122418
P8	9847500	0.181829
P13	39390	0.151775
P15	472680	0.235636

After solving the model by *Gams* Software the optimal solution of the problem indicates the selection ,The optimal value of the objective function of the problem in this case is 2,120,000. the result of selected projects are shown in table5.

TABLE V
RESULTS OF PROJECT SELECTION

Projects	Selection status
P1	selected
P5	selected
P8	rejected
P13	rejected
P15	selected

V. Conclusion

Project selection is the basis of project maangement system. Selection of an optimal project portfolio is an important and strategic decision in project-based organizations. Selecting the right project is always a difficult task for decision maker. In this regard in the paper, attempts were in order to develop a structure by selecting an optimal portfolio of projects by MCDM techniques and Knapsack approach, so that it can regard the existing real situations like organizational constraints when having the most matching with the expert' views. Despite the presented structure in this paper, in order to make it more applicable it can be suggested to take the uncertainty about time and budget of projects for further studies due to the lack of certainty of the estimated values.

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