Project Selection by Using an Integrated Clustering and ANP method: a Case study

Azam Keshavarz Haddadha[1], Zahra Jalilibal[2], Siamak Haji Yakhchali[3]

***Abstract*—** project selection is an important function for organizations. This task for a decision maker can be viewed as a complicated multi criteria decision making (MCDM) problem, which requires consideration of a number of conflicting, tangible and intangible selection criteria. In this research, the purpose of methodology is to clustering and selecting optimal project portfolio in organizations. The proposed approach of this paper first cluster different projects based on k-means algorithm and then rank and select projects with ANP.

***Keywords*—** K-Means clustering, ANP, Project selection.

I. Introduction

THESE days All organizations have to select the projects which are determined to pursue among numerous opportunities[11]. Also project selection is one of the biggest concerns of organizations .one of the most important issues in managerial decision making is Project selection. in recent years, many multi criteria decision making (MCDM) methods have been developed for optimizing project Selection problems. Many researchers have applied these methods into many organizations and several fields.

For project selection, [14] presented Vikor and AHP methods for project selection problem. [8] applied AHP and ANP to for project investment selection.. [7] presented a fuzzy ELECTRE and Topsis method for selecting the best project. However, a number of studies have shown that VIKOR obtain better results against TOPSIS method ([6], [11]). The summarized literature review in project selection problem are shown in table1.

TABLE I LITERATURE REVIEW OF PROJECT SELECTION

refrence	year	Methods
[2]	2015	DEAMATEL-ANP
[5]	2015	GP
[13]	2015	DEAMATEL-ANP
[14]	2015	AHP-Vikor
[17]	2014	AHP-FTopsis
[9]	2013	Topsis -GP
[16]	2013	Knapsack
[3]	2010	AHP-Fuzzy Topsis
[18]	2007	0-1 goal programming
[10]	1998	AHP- GP

Alaodoleh Semnani Institute Of Higher Education, Iran , phone: 09351225295, email:azam.keshavaez1369 .gmail.com

Zahra2. Jalilibal2, Department of Industrial Engineering, College of Engineering, University of Tehran, Tehran, Iran, email: Zjalili222@ut.ac.ir

Siamak3, Haji Yakhchali3, Department of Industrial Engineering, College of Engineering, University of Tehran, Tehran, Iran, email:Yakhchali@ut.ac.ir

This paper presents at first by K-means algorithm cluster projects in each portfolio then evaluating and selecting suitable projects from each cluster by ANP technique. To achieve this purpose, the rest of this paper is organized as follows: In section 2, K-means algorithm is explained. Section 3 discusses ANP technique for Evaluating and project selection. In order to evaluate efficiency proposed Model, a case study is investigated in section 4. Finally, in Section 5, we draw conclusions and future researches.

II. K-Means Algorithm

K-means is a suitable algorithm for clustering a portfolio of projects. So, k-means help to decision maker in choosing of projects. In our study, portfolio of projects created by using of k-means algorithm. In the other words, clusters in k-means algorithm play role of portfolio in project selection problems.It can decreases risks by diversificationis the projects.

The steps of this algorithm is as follow:[1]

Stage 1:

Choose k number of initial cluster centers

Stage2:

A point $X_i(i = 1,2,\dots,n)$ assign to kth cluster if : $\|X_i - Z_l\| \le \|X_i - Z_p\|$, $p = 1,2,\dots.k$

Stage3:

New cluster center compute such as: $Z_i^{new} = \frac{1}{n_i}\sum_{x_i \in s_i} X_i$

where n_i is the number of data points assigned to the clusterS_i

stage4:

if: $\|Z_i^{new} - Z_i\| \in i = 1,2,\dots,k$

then finish , otherwise start from stage 2.

III. 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 [4], [3] Additionally, AHP models have been used effectively to optimize project selection in the research and development settings [3].

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 [15].

Let a_{ij} denote the comparison of the strength of criterion i to j criterion. Based on a priority vector $w = (w_1, \dots, w_n)$ for the overall goal, criteria and alternatives determined by the decision-maker, the pairwise comparison of criterion i to j criterion is computed by $a_{ij} = w_j / w_i$ similarly, And thus, $a_{ji} = 1/a_{ij}$. Then, for the set of decision criteria $e = \{e_j, j = 1, \dots, n\}$ the pairwise comparison of *n* criteria can be summarized in the matrix**:**

$$A = \begin{matrix} a_{11} & \cdots & a_{1j} & \cdots & a_{1n} \\ \vdots & & \vdots & & \vdots \\ a_{i1} & \cdots & a_{ij} & \cdots & a_{in} \\ \vdots & & \vdots & & \vdots \\ a_{n1} & \cdots & a_{nj} & \cdots & a_{nn} \end{matrix}$$

Where every element $a_{ij} (i, j = 1, \dots, n)$ is the quotient of weights of the criteria. The priority vector, or relative weights, of the set of criteria are determined by the right eigenvector *w* of matrix A which corresponds to the largest eigenvalue λ_{max}, i.e. AW= λ_{max}w . This is necessary because the matrix is formed based on human value judgments which are intrinsically inconsistent and this method can provide validity of the priorities of a decision (Saaty, 2003). A pairwise comparison and subsequent eigenvalue calculation is completed by the decision-maker for each criteria and set of sub criteria. The final score of $\tau_i, i = 1, \dots, M$ for each alternative is obtained by summing each alternative's relative weight with respect to each criteria multiplied by the criteria's priority with respect to the goal.

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 [3]. 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 super matrix 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 super matrix allows for interdependence between all of the elements (criteria and alternatives).

In next section the proposed model will be shown in case study.

IV. Empirical Study And Results

In this paper, we use Clementine®12.0 software for clustering projects by k-means algorithm.

Figure 1 shows 3 portfolios of projects. In this case for ranking projects in each cluster we use ANP. Table 5 shows the results of clustering and ranking by Clustering and ANP.

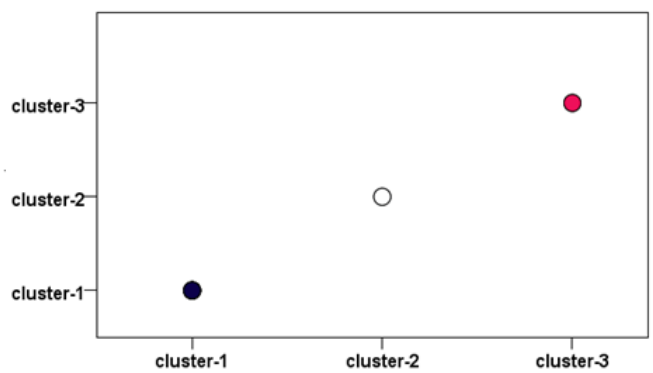

Fig. 1 Results of k-means algorithms clustering to find three clusters

TABLE II
PROJECTS OF EACH CLUSTER

Cluster1	Cluster2	Cluster3
P1	P2	P3
P5	P4	P9
96	P7	P10
P8	P14	P11
P12	P16	P13
	P18	P15
	P19	P17
	P21	P20
	P22	P23
	P25	P24

After clustering projects by k-means Algorithm, in next step with ANP method, we have to rank and select optimal projects from each cluster.

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 III
IDENTIFIED CRITERIA

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

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 4 and 5 and also figure 2 to 4.

TABLE IV
WEIGHTS OF CRITERIA TYPE

Criterion Type	Weight
Organizational factors	
Executive factors	
Economic factors	
Market factors	

TABLE V
WEIGHTS OF CRITERIA

criteria	Criterion	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

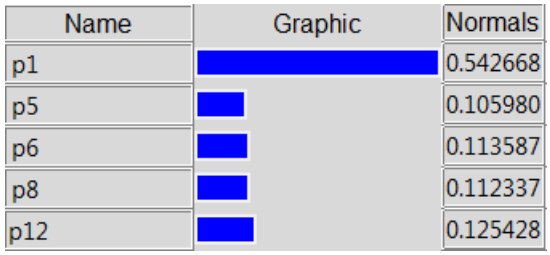

Fig. 2 results of ranking projects in cluster1

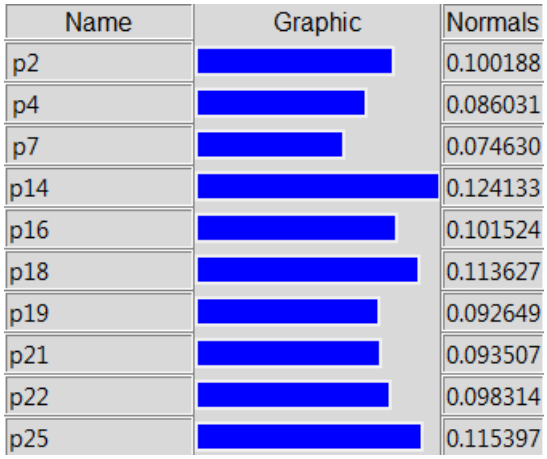

Fig. 3 results of ranking projects in cluster2

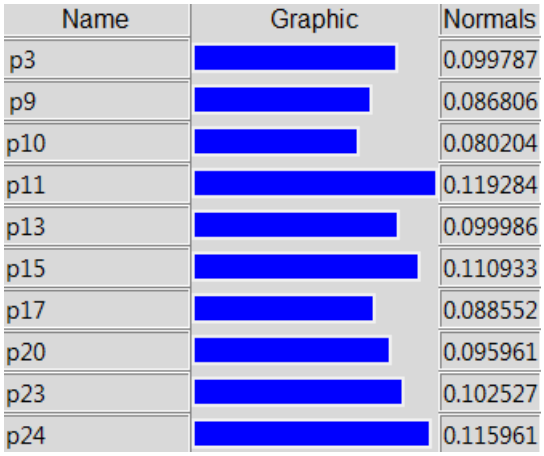

Fig. 4.results of ranking projects in cluster3

Selected projects in each cluster

The results of selected projects in each cluster are given in table6. For each cluster 2 projects that are more important than other are selected.

TABLE VI
RESULTS OF SELECTED PROJECTS

Selected projects	weight	The cluster
P1	0.542	1
P12	0.125	1
P14	0.124	2
P25	0.115	2
P11	0.119	3
P24	0.115	3

V. Conclusion

Project selection is the basis of PM 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. This study proposes a model for the project selection problem where we are encountered with these Issues: how to cluster and rank efficient project portfolios. So, this work has proposed a framework to help decision makers in the project selection problem.

References

[1] Abbas Toloie Eshlaghy, A hybrid grey-based k- means and genetic algorithm for project selection. " *Int. J. Business Information Systems, Vol. 18, No. 2*, 2015.

[2] Altuntas, Serkan., Dereli, Turkay., "A novel approach based on DEMATEL method and patent citation analysis for prioritizing a portfolio of investment projects." Expert Systems with Applications, Vol 42, Issue 3, 15 Feb 2015, pp. 1003–1012.

[3] Amiri Pakdin, Morteza., "Project selection for oil-fields development by using the AHP and fuzzy TOPSIS methods." Expert System With Applications, Vol37, Issue 9, sep2010, pp.6218-6224.

[4] Badri, Masood A., Davis,Donald.,Davis,Donna., "A Comprehensive 0-1 goal programming model for project selection." International journal or Project Management, 2001, pp.243-252.

[5] Ballestero, Enrique ., Garcia, Ana., Hilario, Adolfo., "Portfolio Selection by Goal programming Techniques." International series in operational Research & Management science 219, 2015,pp. 111-129.

[6] Chu, M. T., Shyu, J., Tzeng, G. H., & Khosla, R. "Comparison among three analytical methods for knowledge communities group-decision analysis." *Expert Systems with Applications*, 2007: pp.33(4).

[7] Daneshvar Rouyendegh, B., & Erol, S. "Selecting the best project using the Fuzzy ELECTRE Method." n.d.

[8] F. C.-G. Pablo Aragonés-Beltrán, Juan-Pascual Pastor-Ferrando and Andrea Pla-Rubio, "An AHP (Analytic Hierarchy Process)/ANP (Analytic Network Process)-based multi-criteria decision approach for the selection of solar-thermal power plant investment projects," *Energy*, vol. 66, pp. 222-238, 2014.

[9] Khalili-Damghani, Kaveh., Sadi-Nezhad, Soheil., "A hybrid fuzzy multiple criteria group decision making approach for sustainable project selection." Applied Soft Computing 13, 2013, pp.339–352.

[10] Khoramshahgol, Reza.,Azani,Hossein.,Gousty.,Yvon., "An Integrated Approach to Project Evaluation and." Engineering Management,vol35,Issue4, 1988.

[11] Pangsri, Prapawan .,"Application of the Multi Criteria Decision Making Methods for Project Selection." Universal Journal of Management 3(1), 2015, pp.15-20.

[12] Raei, R., & Jahromi, M. "Portfolio optimization using a hybrid of fuzzy ANP, VIKOR and TOPSIS." *Management Science Letters2(7)*, 2012: pp.2473-2484.

[13] Rezaeian, J., Akbari,F., "Stock portfolio selection using a hybrid fuzzy approach: a case study in Tehran Stock Exchange." International Journal of Operational Research, Vol22, Issue4, 2015.

[14] Salehi, Kayvan., "A hybrid fuzzy MCDM approach for project selection problem." Decision Science Letters ,4, 2015, pp.109–116.

[15] T. L. Saaty, "Decision making with the analytic hierarchy process," *International Journal Services Sciences*, vol. 1, 2008.

[16] Tavana, M., khalili,K., abtahi,A., "A fuzzy multidimensional multiple-choice knapsack model for project portfolio selection using an evolutionary algorithm." New York : @Springer Science+Business Media, Vols. 206, 2013, pp.449–483.

[17] Taylan, O., A.O. Bafail, R.M.S. Abdulaal, Kabli., "Construction projects Selection and risk assessment by Fuzzy AHP and Fuzzy TOPSIS methodologies." Applied Soft Computing Journal ,vol.17, Apr2014, pp.105-116.

[18] Tripathy, B.B ., Biswal,M.P., "A zero-one goal programming approach for project selection." Journal of Information and Optimization Sciences,vol28,Issue 4, 2007, pp.619-626.