A Soft- Computing Approach for Multi Criteria Project Selection Problem with Grey Number

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ABSTRACT

Multi-criteria decision support systems are used in various fields of human activities. In every alternative multi-criteria decision making problem can be represented by a set of properties or constraints. The properties can be qualitative & quantitative. For measurement of these properties, there are different unit, as well as there are different optimization techniques. Depending upon the desired goal, the normalization aims for obtaining reference scales of values of these properties. This paper deals with the multi-attribute Complex Proportional Assessment of alternative. In order to make the appropriate decision and to make a proper comparison among the available alternatives Analytic Hierarchy Process (AHP) under fuzziness and COPRAS method with grey numbers has been used. The uses of AHP is for analysis the structure of the project selection problem is used under fuzziness and to assign the weights of the properties and the COPRAS-G method is used to obtain the final ranking and select the best one among the projects. To illustrate the above mention methods survey data on the expansion of optical fiber for a telecommunication sector is reused. The decision maker can also used different weight combination in the decision making process according to the demand of the system.COPRAS-G method is used to evaluate the overall efficiency of a project with the criterion values expressed in terms of intervals. It is based on the real conditions of decision making and applications of the grey number theory.

General Terms

Project Management and Optimization.

Indexing terms

 Multi-criteria Decision Making, COPRAS-G, AHP, Fuzziness.

Academic Discipline And Sub-Disciplines

Project Selection algorithm.

SUBJECT CLASSIFICATION

Fuzzy Mathematics

INTRODUCTION

MCDM problems are encountered under various situations where a number of alternative and criteria need to be chosen based on a set of attributes. Decision making analysis is based on MCDM theory. The three founder of decision making analysis are Howard, Keeney and Raiffa. [1,2]. The analysis of the purpose is to be achieved by using attributed of effectiveness, which have different dimensions, different weight as well as different directions of optimization. The discrete attribute values can be normalized by applying different normalization method. According to Hwang and Yoon [3] Multi-criteria decision making (MCDM) is applied to preferable decisions among available classified alternatives by multiple attributes. So MCDM is one of the most widely used decision methodology in project selection problems. The MCDM is a method that follows the analysis of several criteria, simultaneously. In this method economic, environmental, social and technological factors are considered for the selection of the project and for making the choice sustainable [4-6]. Several framework have been proposed for solving MCDM problems, namely Analytical Hierarchy Process[AHP] [7,8,9],Analytical Network Process[ANP] [10],which deals with decisions in absence of knowledge of the independence of higher level elements from lower level elements and about the independence of the elements within a level. Other framework available are data envelopment analysis (DEA),Technique for order performance by similarity to ideal solution (TOPSIS) [11-12],VIKOR, COPRAS [13], with grey number,[14-16],Simple Additive weighting (SAW) etc [17], LINMAP [18].With these techniques alternative ratings are measured, weight of the criteria are expressed in precise numbers .The projects' life cycle assessment is to be determined and the impact of all actors is to be measured. There are some mandatory axioms that the criteria describing feasible alternatives are dimensions which are important to determine the performance.

Grey Systems in Decision-Making

Grey system theory was developed by Deng [19] .This theory is very useful in decision making process. Grey system is based on Grey numbers. A grey number is a number whose exact value is unknown, but a range within which the value lies is known. There are various types of Grey numbers:

i) Grey numbers with only lower limits.

ii) Grey numbers with only upper limits.

iii) Interval Grey numbers

iv) Continuous Grey numbers

v) Discrete Grey numbers

vi) Black and white Grey numbers

The theory of grey systems mainly consists of the grey system analysis, grey system modeling, grey decision making and control.

METHODS

Fuzzy AHP Method

The fuzzy AHP technique can be viewed as an advanced analytical method developed from the traditional AHP. According to the method of Chang's (1992) [20] extent analysis, each criterion is taken and extent analysis for each criterion, g_i's performed on, respectively. Therefore, m extent analysis values for each criterion can be obtained by using following notation:

$$M_{g_i}^1 , M_{g_i}^2 , M_{g_i}^3 , M_{g_i}^4 , M_{g_i}^5 .... M_{g_i}^m$$

where g_i is the goal set (i = 1,2,3,4,...................n) and all $M_{g_i}^j$ (j = 1,2,3,4,........m) are Triangular Fuzzy Numbers(TFNs). The steps of the analysis can be given as follows:

Step 1:- Perform the fuzzy addition operation of $M_{g_i}^j$ (j=1, 2... m). The fuzzy synthetic extent value (S_i) with respect to the ith criterion is defined as equation (1):-

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes (1 / [\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j]) \qquad (1)$$

To obtain $\sum_{j=1}^{m} M_{g_i}^j$

Perform the fuzzy addition operation of m extent analysis values for a particular matrix given in equation (3) below, at the end step of calculation, new (l, m, and u) set is obtained and used for the next:-

$$\sum_{j=1}^{m} M_{g_i}^j = (\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j) \qquad (2)$$

Where l is the lower limit value, m is the most promising value and u is the upper limit value and to obtain equation (2):-

$$(1 / [\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j])..m)$$ values given as equation (3):-

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j = (\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i) \qquad (3)$$

and then compute the inverse of the vector in the equation (3) and equation (4) is then obtained as:-

$$(1 / [\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j]) = [\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}] \qquad (4)$$

Step 2:- The degree of possibility of

$$M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$$ is defined as equation (5):-

$$V(M_2 \geq M_1) = \sup [\min(\mu_{M1}(x), \mu_{M2}(y))] \qquad (5)$$

$$y \geq x$$

and x and y are the values on the axis of membership function of each criterion. This equation can be written as

$$V(M_2 \geq M_1) = 1, \qquad \text{if } m_2 \geq m_1$$

$$= 0, \qquad \text{if } l_1 \geq u_2$$

$$= \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, \text{ otherwise} \qquad (6)$$

Step 3:- The degree possibility for a convex fuzzy number to be greater than k convex fuzzy number M_i (i= 1,2,3...............k) can be defined by V (M ≥ M_1, M_2, M_3 .... M_k) = min V (M≥ M_i), i = 1, 2 ...k. Assume that equation (7) is

$$d^*(A_i) = \min V(S_i \geq S_k) \qquad (7)$$

For k = 1, 2, 3.................n; k ≠ i. Then the weight vector is given by equation (8):-

$$W^* = (d^*(A_1), d^*(A_2), ...d^*(A_n))^T \qquad (8)$$

Where A_i (i = 1, 2, 3 ...n) are n elements.

Step 4:- Via normalization, the normalized weight vectors are given in equation (9):-

$$W = (d(A_1), d(A_2), d(A_3) ...d(A_n))^T \qquad (9)$$

Where W is non-fuzzy numbers.

COPRAS-G METHOD

COPRAS-G method is used to evaluate the overall efficiency of a project with the criterion values expressed in terms of intervals. It is based on the real conditions of decision making and applications of the grey number theory. The COPRAS-G method uses a stepwise ranking and evaluating procedure of the alternatives in terms of significance and utility degree.

The steps of COPRAS-G method are as follows:

Step1: Selecting the set of the most important attributes, describing the alternatives.

Step2: Constructing the decision making matrix

$$\otimes X \otimes X = \begin{pmatrix} \otimes x_{11} & \ldots & \otimes x_{1m} \\ \vdots & \ddots & \vdots \\ \otimes x_{n1} & \cdots & \otimes x_{nm} \end{pmatrix} = \begin{pmatrix} [w_{11}; b_{11}] & \ldots & [w_{1m}; b_{1m}] \\ \vdots & \ddots & \vdots \\ [w_{n1}; b_{n1}] & \cdots & [w_{nm}; b_{nm}] \end{pmatrix}$$

$$j=1,........n \text{ and } i=1,.......m$$

where $\otimes x_{ji}$ is determined by w_{ji} (the smallest value, the lower limit) and b_{ji} (the biggest value, the upper limit)

Step 3: Determining weight of the attributes q_i.

Step 4: Normalizing the decision making matrix $\otimes X$

$$\overline{w_{ji}} = \frac{w_{ji}}{\frac{1}{2}(\sum_{j=1}^{n} w_{ji} + \sum_{j=1}^{n} b_{ji})} = \frac{2w_{ji}}{(\sum_{j=1}^{n} w_{ji} + \sum_{j=1}^{n} b_{ji})};$$

$$b_{ji} = \frac{b_{ji}}{\frac{1}{2}(\sum_{j=1}^{n} w_{ji} + \sum_{j=1}^{n} b_{ji}} = \frac{2b_{ji}}{(\sum_{j=1}^{n} w_{ji} + \sum_{j=1}^{n} b_{ji}};$$ ....(2)

i=1,...........n and j=1,...........m

$$\otimes \tilde{x} = \begin{pmatrix} [\otimes \bar{x}_{11}] & \dots & [\otimes \bar{x}_{1m}] \\ \vdots & \ddots & \vdots \\ [\otimes \bar{x}_{n1}] & \cdots & [\otimes \bar{x}_{nm}] \end{pmatrix} = \begin{pmatrix} [\bar{w}_{11;}\bar{b}_{11}] & \dots & [\bar{w}_{1m;}\bar{b}_{1m}] \\ \vdots & \ddots & \vdots \\ [\bar{w}_{n1;}\bar{b}_{n1}] & \cdots & [\bar{w}_{nm;}\bar{b}_{nm}] \end{pmatrix}$$

Step 5: Calculating the weighted normalized decision making matrix $\otimes \tilde{x}$. The weighted normalized values $\otimes \tilde{x}_{ji}$ are calculated as follows:

$$\otimes \vec{x_{ji}} = \otimes \bar{x_{ji}}.q_{i;}$$
$$\vec{w_{ji}} = \bar{w_{ji}}.q_{i;}$$ ....(3)
$$\vec{b_{ji}} = \bar{b_{ji}}.q_{i;}$$

In formula (3) q_i is the weight of the ith attribute. Then the decision making matrix is normalized:

$$\otimes \vec{x} = \begin{pmatrix} [\otimes \vec{x}_{11}] & \dots & [\otimes \vec{x}_{1m}] \\ \vdots & \ddots & \vdots \\ [\otimes \vec{x}_{n1}] & \cdots & [\otimes \vec{x}_{nm}] \end{pmatrix} = \begin{pmatrix} [\vec{w}_{11;}\vec{b}_{11}] & \dots & [\vec{w}_{1m;}\vec{b}_{1m}] \\ \vdots & \ddots & \vdots \\ [\vec{w}_{n1;}\vec{b}_{n1}] & \cdots & [\vec{w}_{nm;}\vec{b}_{nm}] \end{pmatrix}$$ ....(4)

Step 6: Calculating the sums P_j of the attribute values, whose larger values are more preferable.

$$P_j = \frac{1}{2}\sum_{i=1}^{k}(\vec{w_{ji}} + \vec{b_{ji}})$$ ....(5)

Step 7: Calculating the sums R_j of attribute values , whose smaller values are more preferable:

$$R_j = \frac{1}{2}\sum_{i=k+1}^{m}(\vec{w_{ji}} + \vec{b_{ji}}); i = \overline{k,m}$$ ....(6).

Step 8: Determine the minimal value of R_j:

$$R_{\min} = \min_j R_j; j = \overline{j,n}$$ ....(7).

Step 9: Calculating the relative weight of each alternative Q_j:

$$Q_j = P_j + \frac{\sum_{j=1}^{n} R_j}{R_j \sum_{j=1}^{n} \frac{1}{R_j}}$$ ....(8)

Step 10: Determine the optimality criterion k:

$$k = \max_j Q_j; j = \overline{1,n}$$ ....(9)

Step 11: Determine the priority of the project.

Step 12: Calculating the utility degree of each alternative:

$$N_j = \frac{Q_j}{Q_{\max}}100\%$$ ....(10)

where Q_j and Q_{max} are the weight of projects obtained from equation (8).

Proposed Model

The proposed model for the project selection problem [21], composed of Fuzzy AHP and COPRAS-G methods consists of three basic stages: identification of properties, weight assigning and evaluation of alternatives and determine final rank. Based on proposed methodology, the present researcher selects some criteria like:

Net Present Value

The Net Present Value (NPV) is defined as the sum of the present values (PVs) of the individual cash flows. Actually NPV is an indicator of how much value a project adds to the organization. So it is treated as the benefit criteria of the project. In financial theory, if there is a choice between two mutually exclusive alternatives, the one yielding the highest NPV should be selected. So if the value of NPV is positive, the project may be accepted.

Rate of Return

Rate of return (ROR) is the ratio of money gained or lost on a project relative to the amount of money invested. ROR is usually expressed as a percentage. So ROR is also the benefit criteria for any project selection.

Payback Period

Payback period is the period of time required for the return on an investment or project. Payback period has no explicit criteria for decision making. Any project yielding the quickest Payback Period should be selected.

Project Risk

There may be some external circumstances or event that cannot occur for the project to be successful. The external events are called project risks. If such type event is likely to happen, then it would be a risk. The aim of project selection is to minimize the risk criteria.

After identifying these criteria, their weights are found by AHP method. Five homogeneous experts help us to specify the weight.

Case Study of Proposed Model

According to expert's decision, the following matrix is formed and then by using Triangular Fuzzy Number the Fuzzy evaluation matrix is formed

TABLE I.   EVALUATION MATRIX

Criteria	NPV	ROR	PB	PR
NPV	1	1	2	1
ROR	1	1	2	2
PB	0.5	1	1	1.33
PR	0.5	0.5	0.75	1

TABLE II.   FUZZY EVALUATION MATRIX

Criteria	NPV	ROR	PB	PR
NPV	(1,1,1)	(0.75,1,1.25)	(1,2,3)	(0.75,1,1.25)
ROR	(0.8,1,1.33)	(1,1,1)	(1,2,3)	(1.33,2,4)
PB	(0.33,0.5,1)	(0.8,1,1.33)	(1,1,1)	(1,1.33,2)
PR	(0.25,0.5,0.75)	(0.33,0.5,1)	(0.5,0.75,1)	(1,1,1)

Now calculating all the values by applying Chang's [20] theory the following results are obtained:

S_{NPV} = (3.5, 5, 6.5) $\otimes$ (0.04, 0.057, 0.078)= (0.14, 0.28, 0.51)

S_{ROR} =(4.13, 6, 9.33) $\otimes$ (0.04, 0.057, 0.078)=(0.17, 0.34, 0.73)

S_{PB} =(3.13, 3.83, 5.33) $\otimes$ (0.04, 0.057,0.078)=(0.13,0.22, 0.42)

S_{PR} =(2.08, 2.75, 3.75) $\otimes$ (0.04,0.057,0.078)= (0.08,0.16, 0.29)

$V(S_{NPV} \geq S_{ROR}) = 0.85, V(S_{NPV} \geq S_{PB}) = 1, V(S_{NPV} \geq S_{PR}) = 1$

$V(S_{ROR} \geq S_{NPV}) = 1, V(S_{ROR} \geq S_{PB}) = 1, V(S_{ROR} \geq S_{PR}) = 1$

$V(S_{PB} \geq S_{NPV}) = 0.82 \; V(S_{PB} \geq S_{ROR}) = 0.67, V(S_{PB} \geq S_{PR}) = 1$

$V(S_{PR} \geq S_{NPV}) = 0.55, V(S_{PR} \geq S_{ROR}) = 0.4, V(S_{PR} \geq S_{PB}) = 0.73$

Minimum of all values (0.85, 1, 0.67, and 0.4)

The weight W = (0.29, 0.34, 0.23, 0.14)

TABLE III. PROBLEM DESCRIPTION TABLE FOR COPRAS-G METHOD

Serial No.	Set of criteria for evaluation	Variable	Optimal	Unit of Measurement	Weight
1	Net Present Value (NPV)	X_1	MAX	Rs. (Rupees)	0.29
2	Rate of Return (ROR)	X_2	MAX	Rs. (Rupees)	0.34
3	Payback Period (PB)	X_3	MIN	Days (Month)	0.23
4	Project Risk (PR)	X_4	MIN	–	0.14

TABLE IV. INITIAL DECISION MATRIX

Alternatives	NPV (+)	ROR (+)	PB (-)	PR (-)
P1	10	3	6	7
P2	13	5	7	9
P3	9	1	8	1
P4	11	3	8	7
P5	12	5	10	

TABLE V. INITIAL DECISION MATRIX WITH GREY NUMBERS

	0.29(+)		0.34(+)		0.23(-)		0.14(-)	
	NPV		ROR		PB		PR	
	$\otimes$ x1		$\otimes$ x2		$\otimes$ x3		$\otimes$ x4	
	w1	b1	w2	b2	w3	b3	w4	b4
P1	10	13	3	5	5	7	7	9
P2	8	11	2	3	5	8	5	7
P3	8	12	2	5	8	10	4	5
P4	6	9	1	1	6	8	1	1
P5	7	10	2	3	4	6	5	7
$\sum$	39	55	10	17	28	39	22	29
$\sum$ w1+b1	94		27		67		51	

TABLE VI.   NORMALIZED MATRIX

	0.29(+)		0.34(+)		0.23(-)		0.14(-)	
	NPV		ROR		PB		PR	
	⊗ x1		⊗ x2		⊗ x3		⊗ x4	
	w1	b1	w2	b2	w3	b3	w4	b4
P1	0.256	0.236	0.3	0.294	0.179	0.179	0.318	0.310
P2	0.205	0.200	0.2	0.176	0.179	0.205	0.227	0.241
P3	0.205	0.218	0.2	0.294	0.286	0.256	0.182	0.172
P4	0.154	0.164	0.1	0.059	0.214	0.205	0.045	0.034
P5	0.179	0.182	0.2	0.176	0.143	0.154	0.227	0.241

TABLE VII.   WEIGHTED NORMALIZED MATRIX

	Pessimistic				Optimistic			
	$\overline{x1}$	$\overline{x2}$	$\overline{x3}$	$\overline{x4}$	$\overline{x1}$	$\overline{x2}$	$\overline{x3}$	$\overline{x4}$
P1	0.074	0.102	0.041	0.045	0.068	0.099	0.041	0.043
P2	0.059	0.068	0.041	0.032	0.058	0.059	0.047	0.034
P3	0.059	0.068	0.066	0.025	0.063	0.099	0.059	0.024
P4	0.045	0.034	0.049	0.006	0.047	0.020	0.047	0.004
P5	0.052	0.068	0.033	0.032	0.053	0.059	0.035	0.034

TABLE VIII.   NORMALIZED MATRIX WITH COPRAS-G

	0.29(+)		0.34(+)		0.23(-)		0.14(-)	
	NPV		ROR		PB		PR	
	⊗ x1		⊗ x2		⊗ x3		⊗ x4	
	w1	b1	w2	b2	w3	b3	w4	b4
P1	0.213	0.277	0.222	0.370	0.149	0.209	0.275	0.353
P2	0.170	0.234	0.148	0.222	0.149	0.239	0.196	0.275
P3	0.170	0.255	0.148	0.370	0.239	0.299	0.157	0.196
P4	0.128	0.191	0.037	0.037	0.179	0.239	0.020	0.020
P5	0.149	0.213	0.148	0.222	0.119	0.179	0.196	0.275

TABLE IX.   WEIGHTED NORMALIZED MATRIX IN COPRAS-G

	Pessimistic				Optimistic			
	max	max	max	max	min	min	min	min
P1	0.062	0.080	0.075	0.126	0.034	0.048	0.039	0.049

P2	0.049	0.068	0.050	0.075	0.034	0.055	0.027	0.039
P3	0.049	0.074	0.050	0.126	0.055	0.069	0.022	0.027
P4	0.037	0.055	0.013	0.013	0.041	0.055	0.003	0.003
P5	0.043	0.062	0.050	0.075	0.027	0.041	0.027	0.039

TABLE X. VALUES IN INTERVAL IN COPRAS-G METHOD

	Pessimistic			Optimistic		
	P_j	R_J	Q_j	P_j	R_j	Q_j
P1	0.176	0.086	0.238	0.167	0.084	0.229
P2	0.127	0.073	0.200	0.117	0.081	0.182
P3	0.127	0.091	0.185	0.162	0.083	0.225
P4	0.079	0.055	0.175	0.067	0.051	0.169
P5	0.120	0.065	0.201	0.112	0.069	0.188

TABLE XI. SOLUTION RESULT & FINAL RANK

Project No	Alternative weight Q_j			Alternative's degree of efficiency N_j			Rank S_j		
	Pessimistic	Optimistic	Interval	Pessimistic	Optimistic	Interval	Pessimistic	Optimistic	Interval
P1	0.238	0.229	0.234	100	100	100	1	1	1
P2	0.200	0.182	0.191	84.03	79.4	81.6	3	4	4
P3	0.185	0.225	0.205	77.7	98.2	87.6	4	2	2
P4	0.175	0.169	0.172	73.5	73.8	73.5	5	5	5
P5	0.201	0.188	0.195	84.4	82.1	83.3	2	3	3

So P1>P3>P5>P2>P4.

According to this combined approach P1 is the best project.

CONCLUSION

In this article, authors proposed a new methodology to provide a simple approach to assess alternative projects and select the best set of project by using a integrated approach of AHP under fuzziness and COPRAS methods with grey numbers. In conclusion, the COPRAS-G method has a promising future in project management field.

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