International Journal of Decision Inelligence
Vol 1, Issue 4, Autumn 2024, 1-15

Comparison and application of multi-criteria decision making methods in the selection of construction projects (Study of Gostar Mehr Atlas project)

mahdi ranjbarzade[a, *]
[a]*Master of Science in Industrial Management, Islamic Azad University, Qazvin, Iran*

Received 02 April 2024; Accepted 05 June 2024

Abstract:

The main goal of this study was to spread more multi-criteria decision making techniques Also, the second goal of this research was to determine the best location to implement the construction project of Atlas Gostar Mehr Method: In this article, multi-criteria decision-making methods were used to select the best location, in such decisions, several indicators that are sometimes contradictory are considered. Findings: Eight indicators of the number of personnel, equipment, company location, experience, proposed cost, quality of materials, delivery time and interaction with local people were extracted and refined by Delphi method, and five indicators of experience, proposed cost, quality of materials, delivery time and interaction It remained that the expert method was used to determine the weight of the indicators, and the most importance was assigned to the index of the proposed cost and the quality of the materials, and the least weight was assigned to the index of interaction. Conclusion: The findings of the research showed different priorities, therefore the Kaplan and Breda method was used to summarize and make the final decision. According to the available indicators and the Breda and Kaplan method, the Sepenta camp was chosen as the best camp for the implementation of the project.

***Keywords*:** multi- criteria decision making, TOPSIS, Kaplan

1. Introduction

For a person who lives in the 21st century, facing the explosion of information is an important and basic category. The increasing volume of information has confronted mankind with a challenge that, on the one hand, with the search and understanding of reliable information, every day new boundaries of knowledge and recognition T and on the other hand, it has put him in the face of a lot of unprocessed information. Now he is facing this important question, what is the way to distinguish the good from the bad in the era of (a lot) of information? In the industry, the ability to use Nowadays, knowledge plays an important role in understanding these complexities, and managers more than ever need the ability to recognize, analyze, refine and draw the most correct knowledge from the mass of information produced for understanding and making decisions. that in a few months, the amount of evidence doubles. A manager in the supply chain process, including ordering, production and communication with the customer, is regularly involved in making decisions and choices. In a decision, a set of factors such as signs, content knowledge, and experience Previously, patterns or even guesses, feelings and emotions affect the type and quality of the manager's choice at the time of decision-making, but considering the importance of management decisions and their effects on the quality of the product or service, it is the best way to identify and analyze the issue and making a decision What is? Or which of the information sources such as clinical experiences, reference books or the latest articles can provide the basis for the best decision? New decision-making processes

2. Literature review

Table 1
Research background

Title	Result	author
Optimized third-generation prospect theory-based three-way decision approach for conflict analysis in multi-scale Z-number information systems	In conclusion, this research significantly contributes to the fields of GrC, TWD theory, and behavioral decision-making by introducing a TGPT-based TWD model that addresses the intricate challenge of capturing DMs' subjective	Tianxing Wang et al 2024

	risk preferences and behaviors in uncertain environments. investigation, grounded in the GrC framework, extends the boundaries of existing methods and advances the modeling and analysis of subjective risk preferences.	
Multi-objective bi-level programs for optimal microgrid planning considering actual BESS lifetime based on WGAN-GP and info-gap decision theory	In view of the shortcomings of GANs and WGANs, such as difficult training, slow convergence rate, and poor sample quality, this paper applies WGAN-GP to wind, PV generation, and load scenario generation, and utilizes the K-medoids reduction technology to obtain several typical scenarios to reduce the calculation burden. The performance of WGAP-GP is better than that of WGANs, the training of WGAP-GP is stable, and almost no parameters are needed to tune.	Hualong Liu AND Wenyuan Tang
Selection of an economics-energy-environment scheduling strategy for a community virtual power plant considering decision-makers' risk attitudes based on improved information gap decision theory	This study first develops a CVPP model using DMRA and a multi-objective satisfaction model that combines economy-energy-environment. Second, the IGDT model is improved to account for uncertainties in RE, load, and DMRA. Then, to make the quadratic optimal selection of the obtained multi-objective strategy, EWM and FUCOM are used to improve VIKOR's method when considering DMRA.	Fangjie Gao et al 2024
Uncertainty and climate change: The IPCC approach vs decision theory	The purpose of the paper was to provide a summary description of the ways in which the IPCC deals with uncertainty in its reports, along with a brief review of the approaches that decision theory and the eco-nomics of climate change use to deal with deep uncertainty defined as ambiguity aversion and misspecification concerns. Uncertainties char-acterizing climate science, the economy and their interrelationships can be regarded as providing a strong case for considering ambiguity, and misspecifications in climate change economics. The IPCC approach to uncertainty as it is communicated through its reports is akin to the concept of risk as it is defined in decision theory, with the notable exception that risk is associated only with the adverse effects of a probabilistic model, while positive effects are called op- portunities. Dealing with risk involves providing intervals of parameter estimates along with their central values for parameters not known with certainty. Qualitative assessments – mainly of climate change impacts –combine evidence, subjective likelihood and agreement among experts.	Anastasios Xepapadeas 2024
A Quantum Group Decision Model for Meteorological Disaster Emergency Response Based on D-S evidence theory and Choquet Integral	Considering the complexity, dynamism, and uncertainty inherent in meteorological disasters, this paper proposes a quantum group decision-making model for meteorological disasters, grounded in evidence theory and the Choquet integral. To address the interplay among attributes, the model integrates information through the 2-additive Choquet integral and evidence theory for effective weight assignment.	Shuli Yan et al 2024
Methodology of multi-criteria decision analysis models	Choosing MODM techniques has uncountable answers and MADM techniques has countable answers. Choosing MADM techniques itself is a MADM problem and there is no special rule for it, but this model can be used as a general selection rule.	Asghar Mohammad Moradi and Mehdi Akhtarkavan 2008

Introducing multi-criteria decision making methods for sewage treatment plant	In the decision-making process, the goal is to determine the best option among the competing options, which is not possible without having a tool that can evaluate different criteria considering their relative importance. Multi-criteria decision making methods with this feature can help to choose the best option.	Hossein Gol and Majid Hosseinzadeh 2019
Fuzzy DENAP-Fuzzy TOPSIS-Dual Objective Mathematical Model approach for the problem of green supplier selection and order allocation and its solution with Harmony Search Algorithm	The decision maker can choose the best solution according to the Pareto solutions of the problem so that a correct balance is made between the chain costs and the purchase value.	Sara Amir Salami and Saeed Alaei 2023
Project management based on multi-criteria decision making process.	AHP is an effective method in MCDM multi-criteria decision-making, and its use in different stages of project management will be useful for managers in decision-making.	Mohammadreza Filizadeh and Hassan Sadeghi 2015
Choosing the right job with the help of multi-criteria decision making techniques	The main job selection criteria have been identified and extracted by the field method and by using relatively new knowledge in the field of decision-making under the title of multi-criteria decision-making and by combining two hierarchical and pyramidal analysis techniques, a decision-making model has been presented.	Zohra Rafzi et al. 2012
Application of multi-criteria decision making model in measuring hospital efficiency	The findings showed that the ratio method is not able to provide the final result in the field of hospital efficiency and compare one hospital with other hospitals due to the limitation in the use of quantitative and qualitative criteria to measure the efficiency of the hospital.	Nahid Hatem and Sogand Turani 2014
Choosing and testing the bankruptcy model with multi-criteria decision criteria	The findings showed that Zemiski and Toffler's model are suitable and financial ratios are different in bankrupt and successful companies. Also, Tofflero Zemiski model is simpler and more understandable for decision makers than other models. Therefore, Delphi and the rank analysis process are suitable techniques to choose.	Mehdi Safari and Omid Islamzadeh, 2015
The application of gray multi-criteria decision making in evaluating the performance of companies	Multi-criteria decision-making, in addition to examining the relationships between factors and different options, includes inputs in the form of interval numbers, which actually displays both the uncertainty in the system structure and the uncertainty in the inputs of the decision-making system.	Ali Mohammadi and Nabi Moulai, 2009

3. Analysis method

Note: Delphi method was used in order to select indicators with more effect: 10 experts were asked to evaluate the Delphi method.

Table 2
Delphi method for extracting important indicators

	Experience	Number of Staff	Suggested cost	Equipment	Quality of materials	Delivery time	Interaction	Company location	
1	8	9	9	9	8	8	9	9	
2	7	9	8	9	9	9	9	8	
3	8	8	8	8	8	9	8	8	
4	8	9	9	8	9	8	9	8	
5	9	8	7	9	9	9	9	8	
6	9	6	9	8	8	8	9	9	
7	9	8	9	8	8	8	8	8	

8	9	9	8	8	8	9	8	8	
9	9	9	8	8	8	9	9	9	
10	8	8	9	8	9	8	9	8	
x	84	83	84	83	84	85	87	83	673
(x-m)2	0/02	1/27	0/02	1/27	0/02	0/77	8/27	1/27	12/88

Formula 1)

$$\boldsymbol{m = \frac{\sum x}{n} = \frac{637}{8} = 84/125}$$

Formula 2)

$$\boldsymbol{v = \sqrt{\frac{\sum(x-m)^2}{n} = \frac{12/88}{8}} = 1/77}$$

Formula 3)

$$\boldsymbol{m - 0.5 * v = 84.125 - 0.5 * 1.77 = 83.24}$$

I
n the next step, x's smaller than 83.24 are removed As a result, indicators of the number of personnel, equipment and location of the company are removed Four camps have volunteered to do this project.

It should be noted that the four camps have been asked to estimate the cost and determine the proposed amount for the project, and also estimate the project implementation time and operational time, and also notify the type and brand of the desired materials.

tip: Experience and quality of materials and interaction with local people, which are three quality indicators that have been measured and graded by an expert civil engineering expert. The cost of the proposal, which is considered a negative indicator, is billions of Tomans. The unit of measurement of delivery time from project implementation, which is a negative index, is month.

Table 3
Initial matrix

	+	-1	+	-1	+
	Experience	**Suggested cost**	**Quality of materials**	**Delivery time**	**Interaction**
Paya saman	9	40	7	5	5
sepanta	8	35	8	7	7
kiewit	6	37	9	6	6
vinci	7	30	6	8	8

Determining the weight of the indicators: In order to get the weight of the indicators, there is an expert method and an entropy method, which was used in this project.

Expert method: In this technique, several experts were asked to rate the indicators from 1 to 10

Table 4
Determination of weights by expert method

	+	-	+	-	+	
	Experience	**Suggested cost**	**Quality of materials**	**Delivery time**	**Interaction**	
a1	9	8	9	9	9	
a2	8	9	8	8	7	
a3	7	8	10	8	8	
a4	8	9	7	7	7	
$\sum x$	32	34	34	32	31	**163**
wj	**0.196**	**0.209**	**0.209**	**0.196**	**0.190**	

4. SAW method:

To do the following steps were followed.

1) De-scaling from the linear method 2) Determining the weights of the indicators 3) Multiplying the unscaled matrix in the column matrix of weights 4) Prioritizing the indicators using the obtained values

Table 5
unscaled matrix multiplied by expert weights

1	0.7500	0.7778	1	0.6250		0.196
0.8889	0.8571	0.8889	0.7143	0.8750		0.209
0.6667	0.8108	1	0.8333	0.7500		0.209
0.7778	1	0.6667	0.6250	1		0.196
						0.190

Table 6
The ranking of the camps

		rank	Priority
Paya saman	0.8302	2	sepanta
sepanta	0.8453	1	Paya saman
kiewit	0.8148	3	kiewit
vinci	0.8132	4	vinci

The second method of TOPSIS technique: To use this method, the following steps were followed
1) Unscaling using the soft or Euclid method 2) Determining the weights of the indices 3) Forming the weighted unscaled matrix To form this matrix, we multiply the weights of the indices by the values of the unscaled matrix

Table 7
Unscaled matrix

	Experience	**Suggested cost**	**Quality of materials**	**Delivery time**	**Interaction**	
Paya saman	0.593	0.560	0.462	0.379	0.379	
sepanta	0.528	0.490	0.528	0.531	0.531	
kiewit	0.396	0.518	0.593	0.455	0.455	
vinci	0.462	0.420	0.396	0.606	0.606	
Wj	0.196	0.209	0.209	0.196	0.190	

Table 8
The weighted scaleless matrix

	+	**-1**	+	**-1**	+	
	Experience	**Suggested cost**	**Quality of materials**	**Delivery time**	**Interaction**	
Paya saman	0.117	0.117	0.096	0.074	0.072	
sepanta	0.104	0.102	0.110	0.104	0.101	

kiewit	0.078	0.108	0.124	0.089	0.087	
vinci	0.091	0.088	0.083	0.119	0.115	

The next step is to determine positive and negative ideals: to determine positive ideals, we chose the largest number in positive indicators and the smallest number in negative indicators, and we did the opposite to determine negative ideals.

Table 9
Positive ideals and negative ideals

A+	0.117	0.088	0.124	0.074	0.115
A-	0.0777	0.1169	0.0825	0.1191	0.0721

The next step is to determine the distance of each option with positive and negative ideals

$\mathbf{d_i^+}=[\sum(\boldsymbol{pij}-\boldsymbol{pj}^+)^2]^{1/2}$

Formula 4)

$$\mathbf{d_i^+}=[(\mathbf{0117-0.117})^2+(\mathbf{0.117-0.088})^2+(\mathbf{0.096-0.124})^2+(\mathbf{0.074-0.074})^2+(\mathbf{0.072-0.115})^2]^{1/2}=\mathbf{0.05901}$$

Formula 5)

$\mathbf{d_i^-}=[\sum(\boldsymbol{pij}-\boldsymbol{pj}^-)^2]^{1/2}$

$$\mathbf{d_i^-}=[(\mathbf{0.117-0.0777})^2+(\mathbf{0.117-0.1169})^2+(\mathbf{0.096-0.0825})^2+(\mathbf{0.074-0.1191})^2+(\mathbf{0.072-0.07721})^2]^{1/2}=\mathbf{0.060}$$

Then, we obtained the relative distance of the options from positive and negative ideals using the following relationship, and according to it, prioritization was done from large to small.

$$\mathbf{CL_i}=\frac{\mathbf{di-}}{\mathbf{di-+di+}}$$

Formula 6)

$$\mathbf{CL_i}=\frac{\mathbf{0.060}}{\mathbf{0.060+0.05901}}\quad=\mathbf{0.5073}$$

The third method of Vicor: 1) We descaled the decision matrix using the soft method 2) Determine the weight of the indicators 3) We determined the highest and lowest value of each index.

Table 11
Unscaled matrix

	+	-1	+	-1	+	
	Experience	**Suggested cost**	**Quality of materials**	**Delivery time**	**Interaction**	
Paya saman	0.593	0.560	0.462	0.379	0.379	
sepanta	0.528	0.490	0.528	0.531	0.531	
kiewit	0.396	0.518	0.593	0.455	0.455	
vinci	0.462	0.420	0.396	0.606	0.606	

Table 12
Weights by expert method

Cli	**di-**	**di+**		rank	Priority
0.5073	0.060752	0.059006	Paya saman	2	sepanta

0.5599	0.051899	0.040794	sepanta	1	Paya saman
0.4955	0.053603	0.054586	kiewit	3	kiewit
0.4487	0.053783	0.066078	vinci	4	vinci

We obtained the highest value and the lowest value of each index

Table 13
The highest and lowest values of the unscaled matrix

Fj+	0.593	0.420	0.593	0.379	0.606
Fj-	0.396	0.560	0.396	0.606	0.379

The next step is to calculate the amount of benefit and regret

Formula 7) $S_i = \sum wj \frac{fj+-fj}{fj+-fj-}$ =

$$(0.1963\frac{0.593-0.593}{0.593-0.396})+(0.2086\frac{0.420-0.560}{0.420-0.560})+(0.2086\frac{0.593-0.462}{0.593-0.396})+(0.1963\frac{0.379-0.379}{0.379-0.606})+(0.1902\frac{0.606-0.379}{0.606-0.379})=0.537$$

Formula 8) $R_i = \max wj \frac{fj+-fj}{fj+-fj-}$

$$max\left(0.1963\frac{0.593-0.593}{0.593-0.396}\right),\left(0.2086\frac{0.420-0.560}{0.420-0.560}\right),$$

$$\left(0.2086\frac{0.593-0.462}{0.593-0.396}\right),\left(0.1963\frac{0.379-0.379}{0.379-0.606}\right),(0.1902\frac{0.606-0.379}{0.606-0.379})=0.208$$

The next step is to determine the value of Vicor Øi: in this regard, we are faced with a value of v that fluctuates between 0 and 1, when we want to value more usefulness, its value is from zero to half, and when we want to value more regret, its value is between It is 0 to 0.5. In this project, the value is (V=0.5).

$$\boldsymbol{Øi}=\boldsymbol{V}\frac{\boldsymbol{Si}-(\boldsymbol{Si}-)}{(\boldsymbol{Si}+)-(\boldsymbol{Si}-)}+(\mathbf{1}-\boldsymbol{V})\frac{\boldsymbol{Ri}-(\boldsymbol{Ri}-)}{(\boldsymbol{Ri}+)-(\boldsymbol{Ri}-)}$$

Formula 9)

The next step is to prioritize options based on three indices Si, Ri, Øi from small to large.

The next step is the final prioritization of the options: the option that is placed in the same rank by all three indicators is evaluated in the same rank. If an option has different ranks in the indicators, Øi subtracts the option from Øi of the first option. If it is less than 1/ n-1) if it is more, it is evaluated in the same rank and if it is less, it is evaluated as equal. In this example, all the options were ranked in the same rank in all indicators

Table 14
Prioritization by Vicor method

Øi	**Ri**	**Si**	**option**	**Øi**	**Ri**	**Si**	**Priority**
1.0000	0.20859	0.537832	Paya saman	sepanta	sepanta	sepanta	sepanta
0.0000	0.130879	0.433538	sepanta	kiewit	kiewit	kiewit	kiewit
0.9054	0.196319	0.53456	kiewit	vinci	vinci	vinci	vinci
0.9902	0.208589	0.535787	vinci	Paya saman	Paya saman	Paya saman	Paya saman

The fourth method of regime method: In this method, we compared all the options in terms of indicators, then we divided the total weight of the indicators that option i is better than option j into the total weight of indicators that option j is better than option i. If this number is positive, it means that option i is better than option j, and if it is negative, it means that option j is better than option i

Table 15
the primary matrix

	+	-1	+	-1	+
	Experience	**Suggested cost**	**Quality of materials**	**Delivery time**	**Interaction**
Paya saman	9	40	7	5	5
sepanta	8	35	8	7	7
kiewit	6	37	9	6	6
vinci	7	30	6	8	8

Table 16
Weights by expert method

wj	0.196	0.209	0.209	0.196	0.190

E(**Paya saman/ sepanta**)=(1,4) (2,3,5)= (0.196+0.196)-(0.209+0.209+0.190)=
-0.21 **sepanta > Paya saman**
E(Paya saman/ kiewit)=(١,4)(٢,3,5)=(0.196+0.196)-(0.209+0.209+0.190)=
-0.21 kiewit > Paya saman
E(Paya saman/ vinci)=(١,٣,4)(٢,5)=(0.196+0.209+0.196)-(0.209+0.190)=
0.202 Paya saman > vinci
E(sepanta/ kiewit)=(١,2,5)(3,4)=(0.196+0.209+0.190)-(0.209+0.196)= 0.19 sepanta> kiewit
E(sepanta/ vinci)=(١,3,4)(٢,5)=(0.196+0.209+0.196)-(0.209+0.190)= 0.202 sepanta > vinci
E(kiewit / vinci)=(3,4)(١,2,5)=(0.209+0.196)-(0.196+0.209+0.190)= -0.190 vinci > kiewit
vinci > Paya saman > kiewit > sepanta

The fifth method of allocation: In this method, the following steps were followed. 1) Determining the weight of indicators (the weight is determined by an expert method) 2) The total weight of the indicators obtained by the options in different ranks was calculated

Table 17
The initial matrix

	+	-1	+	-1	+
	Experience	**Suggested cost**	**Quality of materials**	**Delivery time**	**Interaction**
Paya saman	9	40	7	5	5
sepanta	8	35	8	7	7
kiewit	6	37	9	6	6
vinci	7	30	6	8	8

Table 18
The ranking of camps based on indicators

rank	**Experience**	**Suggested cost**	**Quality of materials**	**Delivery time**	**Interaction**
1	Paya saman	kiewit	vinci	Paya saman	kiewit
2	sepanta	sepanta	sepanta	vinci	sepanta
3	kiewit	vinci	Paya saman	sepanta	vinci
4	vinci	Paya saman	kiewit	kiewit	Paya saman

Table 19
The ranking of the camps

	First Place	**Second place**	**third rank**	**Fourth**
Paya saman	0.392	0	0.209	0.19
sepanta	0	0.804	0.196	0
kiewit	0.209	0.196	0.399	0.196
vinci	0.399	0	0.196	0.405

3) In the next step, we applied the Hungarian method for allocation (in the Hungarian method, five steps are assumed for allocation models of the MIN type, and if the model was max, first we subtract the largest table number from the rest of the table numbers so that it becomes min, then like We continue with the min model)
Note: In this example, the largest number in the table is (0.804) and the matrix numbers before it have been subtracted.

Table 20
The subtraction of the largest number from the numbers in Table 19

	0.412	0.804	0.595	0.614
	0.804	0	0.608	0.804
	0.595	0.608	0.405	0.608
	0.405	0.804	0.608	0.399

A) The next step is to determine the smallest number of each row and subtract the numbers of that row from this number

Table 21
Subtraction of the smallest row number in Table 20

	0	0.392	0.183	0.202
	0.804	0	0.608	0.804
	0.19	0.203	0	0.203
	0.006	0.405	0.209	0

b) In the resulting table, we subtracted the smallest number of each column from the numbers of that column

Table 22
Subtracting the smallest column number from Table 21

	0	0.392	0.183	0.202
	0.804	0	0.608	0.804
	0.19	0.203	0	0.203
	0.006	0.405	0.209	0

c) We specify at least the lines with which all zeros can be drawn. If the number of lines is equal to the number of rows and columns, there is no need for the fourth step.

Table 23
Covering zeros with a line

	0	0.392	0.183	0.202
	0.804	0	0.608	0.804
	0.19	0.203	0	0.203
	0.006	0.405	0.209	0

Note: Since the number of lines is equal to the number of rows and columns, we will not do the next step.

d) We consider the smallest number that is not covered by any line. This number is added to the numbers that are located at the intersection of two lines and is subtracted from the numbers that are not cut by the line and the numbers that are only cut by one line are directly transferred to the next table. And we do the third step again. Do this step until the number of rows and columns is equal.

4) In this step, we set the numbers to zero and the zeros to one and multiplied the resulting matrix by the column matrix of the options to determine the priorities.

Table 24
anking based on allocation method

1	0	0	0		Paya saman		Paya saman
0	1	0	0		sepanta	=	sepanta
0	0	1	0		kiewit		kiewit
0	0	0	1		vinci		vinci

vinci > kiewit > sepanta > Paya saman

The sixth method of ELECTRE was applied to use this method, the following steps

Step one and two are the same as the TOPSIS method (de-scaling from the soft or Euclid method, determining the weight of the data and forming a weighted matrix)

Table 25
Unscaled matrix

	+	-1	+	-1	+	
	Experience	**Suggested cost**	**Quality of materials**	**Delivery time**	**Interaction**	
Paya saman	0.593	0.560	0.462	0.379	0.379	
sepanta	0.528	0.490	0.528	0.531	0.531	
kiewit	0.396	0.518	0.593	0.455	0.455	
vinci	0.462	0.420	0.396	0.606	0.606	

Table 26
Weights by expert method

wj	0.196	0.209	0.209	0.196	0.190	

Table 27
The balanced matrix

	+	-1	+	-1	+	
	Experience	**Suggested**	**Quality of**	**Delivery**	**Interaction**	

		cost	materials	time		
Paya saman	0.117	0.117	0.096	0.074	0.072	
sepanta	0.104	0.102	0.110	0.104	0.101	
kiewit	0.078	0.108	0.124	0.089	0.087	
vinci	0.091	0.088	0.083	0.119	0.115	

The next step is to form a coordinated and non-coordinated matrix
For this purpose, when comparing two options, the indicators that the first option is better than the second were included in the coordinated set, and the indicators that the second option is better than the first were included in the inconsistent set (harmonized S) (non-harmonized R).
$S_{12(1,4)}$ $R_{12(2,3,5)}$ $S_{13(1,4)}$ $R_{13(2,3,5)}$ $S_{14(1,3,4)}$ $R_{14(2,5)}$ $S_{23(1,2,5)}$ $R_{23(3,4)}$
$S_{24(1,3,4)}$ $R_{24(2,5)}$ $S_{34(3,4)}$ $R_{34(1,2,5)}$
Forming a coordinated matrix To form a coordinated matrix, we put the sum of the weights of the indicators in the coordinated set at the top of the main diameter of the matrix and the sum of the weights of the non-coordinated indicators at the bottom of the main diameter.

Table 28
The coordinated matrix

-	0.969	0.708	0.969
1	-	0.575	0.531
1	1	-	0.699
1	1	1	-

Formation of uncoordinated matrix: To form the uncoordinated matrix, we form fractions in which the denominator of these fractions is the absolute value of the difference between the numbers of each like-for-like index, and in the case of a fraction, the absolute value of the difference of the indices that are in the uncoordinated set After obtaining the values, we select their maximum and divide the numerator by the denominator.

Formula 10)

$$NI_{12}=\frac{MAX(|0.117-0.102|,|0.096-0.110|,|0.072-0.101|)}{MAX(|0.117-0.104||0.117-0.102||0.096-0.110||0.074-0.104||0.072-0.102|}$$

$$NI_{21}=\frac{MAX(|0.117-0.104|,|0.074-0.104|)}{MAX(|0.117-0.104||0.117-0.102||0.096-0.110||0.074-0.104||0.072-0.102|}$$

Table 29
The uncoordinated matrix

-	0/969	0/708	0/969
1	-	0/575	0/531
1	1	-	0/699
1	1	1	-

Coordinate matrix threshold

Formula 11)

$$\frac{\mathbf{0.392+0.392+0.601+0.595+0.601+0.405+0.608+0.608+0.405+0.399+0.399+0.595}}{12}=0.5$$

Incongruent matrix threshold

$$\frac{0.969 + 0.708 + 0.969 + 0.575 + 0.531 + 0.699 + 1 + 1 + 1 + 1 + 1 + 1}{12} = 0.871$$

The next step is to form the effective and ineffective coordinated matrix: to form the effective matrix, we compared the numbers of the coordinated matrix with the threshold value, if it was greater, we considered 1 and if it was less, we considered zero, but for the effective inconsistent matrix, when we compared the numbers of the inconsistent matrix with the threshold value, more It was zero, it was less, we considered 1.

Table 30
Multiplying the effective matrix by the ineffective matrix

ineffective atris					effective matrix			
—	**0**	**1**	**0**		—	**0**	**0**	**1**
0	—	**1**	**1**		**1**	—	**1**	**1**
0	**0**	—	**1**	X	**1**	**0**	—	**0**
0	**0**	**0**	—		**0**	**0**	**1**	—

Table 31
Matrix multiplication in the base

PAYASAMAN	**SEPANTA**	**KIEWIT**	**VINCI**		
—	**0**	**0**	**0**		**PAYASAMAN**
0	—	**1**	**1**		**SEPANTA**
0	**0**	—	**0**		**KIEWIT**
0	**0**	**0**	—		**VINCI**

Table 32
The ranking of the camps

	rank	**win-loss**	**win**	**Loss**
payasaman	**2**	**0**	**0**	**0**
sepanta	**1**	**2**	**2**	**0**
kiewit	**3**	**-2**	**0**	**2**
vinci	**3**	**-2**	**0**	**2**

vinci = kiewit > payasaman > sepanta

Research findings

After analyzing the options of different techniques, it has been observed that the ranking of each technique can be different from another tactic, therefore, Breda method and Kaplan method are used for summarization.

Table 33
Overall ranking in different methods

	SAW	**TOPSIS**	**VIKOR**	**ELECTRE**	**Assignment**	**REGIME**
Rank 1	sepanta	sepanta	sepanta	sepanta	payasaman	sepanta
Rank 2	payasaman	payasaman	kiewit	payasaman	sepanta	kiewit

Rank 3	kiewit	kiewit	vinci	kiewit = vinci	kiewit	payasaman
Rank 4	vinci	vinci	payasaman	0	vinci	vinci

BORDA and KAPLAN average method:

After finding options from different techniques, it has been observed that the ranking of each technique can be different from another tactic. In the method of average ratings, the total of each option in the technique is calculated and whichever is lower, we rank based on that.

BORDA method

sepanta $=\frac{1+1+1+1+2+1}{6}=1.167$

payasaman $=\frac{2+2+4+2+1+3}{6}=2.334$

sepanta < payasaman< kiewit< vinci

vinci $=\frac{4+4+3+4+3+4}{6}=3.667$

kiewit $=\frac{3+3+2+3+3+2}{6}=2.666$

KAPLAN method

Table 34
Ranking based on the Kaplan method

	sepanta	payasaman	kiewit	vinci	**W**	**W-L**	**RANK**
sepanta	**-**	**5**	**6**	**6**	**17**	**17**	**1**
payasaman	**0**	**-**	**4**	**5**	**9**	**1**	**2**
kiewit	**0**	**2**	**-**	**5**	**7**	**-3**	**3**
vinci	**0**	**1**	**0**	**-**	**1**	**-15**	**4**
L	**0**	**8**	**10**	**16**			

sepanta < payasaman < vinci < kiewit

Conclusion

As you have seen, decision-making techniques and mathematical models, such as multi-criteria decision-making in various fields of social sciences and individual life, where people are always making decisions and choosing the optimal option, can be very useful and fruitful. Especially in the supply chain of projects, where managers are faced with the multitude and diversity of criteria and options, and making the correct comparison and appropriate ranking of options is a very difficult and stressful matter, and the consequences of inappropriate decisions have many negative effects on projects. These tested techniques can reduce the complexity of decision-making and the anxiety of existing conditions and help the decision-maker in making the most appropriate decision. Therefore, in this article, we used some multi-criteria decision-making techniques and combined them with the structure of the problem, and presented an example to explain how to use the techniques, and finally, using the opinions of experts, to validate it. We evaluated it in real conditions and while confirming the correctness of the model's efficiency, we came to the conclusion that its effective output can help the decision maker in the optimization of decision making in the process of choosing the right location in the role of a scientific consultant and decision supporter.

Future Research

1. Use these techniques in product-oriented industries
2. Select supply chain agility indicators
3. Use the ism method to know the relationship between indicators

References

1. Wang, Tianxing, Huang, Bing, Li, Huaxiong, 2024, Optimized third-generation prospect theory-based three-way decision approach for conflict analysis in multi-scale Z-number information systems, Information Sciences, Volume 663, March 2024, 120309
2. Liu, Hualong, Tang, Wenyuan, 2024, Multi-objective bi-level programs for optimal microgrid planning considering actual BESS lifetime based on WGAN-GP

and info-gap decision theory, Journal of Energy Storage, Volume 89, 1 June 2024, 111510

3. Gao, Fangjie, Gao, Jianwei, Huang, Ningbo, Wu, Haoyu, 2024, Selection of an economics-energy-environment scheduling strategy for a community virtual power plant considering decision-makers' risk attitudes based on improved information gap decision theory, Energy,Volume 299, 15 July 2024, 131401
4. Xepapadeas, Anastasios, 2024, Uncertainty and climate change: The IPCC approach vs decision theory, Journal of Behavioral and Experimental Economics, Volume 109, April 2024, 102188
5. Yan, Shuli, Xu, Yizhao, Gong, Zaiwu, Viedma, Enrique Herrera, A Quantum Group Decision Model for Meteorological Disaster Emergency Response Based on D-S evidence theory and Choquet Integral, Information Sciences Available online 10 May 2024, 120707
6. Tasa, Omid, Gulabchi, Mahmoud, Ravanshadnia, Mehdi, 2023, Risk response assessment in complex construction projects using fuzzy TOPSIS method, Tehran University Industrial Management Journal, Volume 15, Number 2, 335-364
7. Modares, Azam, Motahari, Nasser, Bafendangan Mozrozi, Vahidah, 2022, development of the newspaper seller model according to the relative competence of suppliers based on possible group decision-making, Scientific Research Journal of Industrial Management of Tehran University, Volume 14, Number 1, 115-142
8. Ebrahimi Tederar, Ali, 2021, presentation of fuzzy possibility-flexibility hybrid model with fuzzy TOPSIS for mathematical planning problems of financial investment, Tehran University Industrial Management Scientific Research Journal, Volume 13, Number 2, 352-369
9. Khajawi, Shokrallah, Fatahi Navji, Hassan, 2014, comparative study of efficient hybrid algorithms to evaluate financial performance using fuzzy approach (case study: Tehran Stock Exchange companies), University of Tehran Industrial Management Scientific Research Journal, Volume 7, No. 2, 285-304
10. Mohammadi Mutlaq, Hasan Ali, Mohammadi Mutlaq, Alireza, 2014, Designing an expert system for supplier evaluation and selection, Scientific Research Journal of Industrial Management of Tehran University, Volume 7, Number 2, 385-403
11. Zarei Mahmoodabadi, Mohammad, Tahari Mehrjardi, Mohammad Hossein, Mahdovian, Alireza, 2013, evaluation of research and development activities in Iran: data coverage analysis approach, volume 6, number 1, 55-74
12. Molavi, Behnam, Esmailian, Majid, Ansari Reza, 2013, presenting a method for prioritizing organizational agility strategies using TOPSIS technique and fuzzy inference system, University of Tehran Industrial Management Scientific Research Journal, Volume 5, Number 1, 123-138
13. Mohammad Moradi, Asghar, Akhtar Kavan, Mehdi, (2008), Methodology of Multi-Criteria Decision Analysis Models, Arman Shahr, No. 2
14. Ahmadvand, Mohsen; Khorasan Chi, Fatemeh and Ahmadvand, Ansieh. (2012) Ranking of requirements for the realization of green supply chain management in Iran police by Fuzzy TOPSIS method, Applied Research Center of Amad Deputy and Naja Support. . 59-79.
15. Azar, Adel; Mahmoudian, Omid; and Hashemi, Mehdi; (2016), presenting a method to evaluate the green supply chain performance of Assalouye Petrochemicals using the combination of fuzzy method and nonlinear modeling, Energy Economy Studies, 12(48): 173-194.
16. Gol, Hossein, Hosseinzadeh, Majid, (2019), Introduction of multi-criteria decision-making methods for wastewater treatment, 11th International Conference on Sustainable Development and Urban Development
17. Hajizadgan, Saida. 2014. "Comparison and application of multi-criteria decision-making methods in selecting the optimal process for wastewater treatment". Imran's master's thesis, Birjand University.
18. Qudsipour, Sidhsan. 2015. "Multi-objective programming of ten-dimensional weighting methods after solving". Tehran: Amirkabir University of Technology Publications.
19. Qudsipour, Sidhsan. (2008) "Debates in multi-criteria decision making: Hierarchy analysis process", Amir Kabir Industrial University Publications
20. Mirabi, Mehrdad, Mian Abadihojat, Sharifi, Mohammad Baqer. 2013 "The application of multi-criteria decision making in choosing the appropriate option for the collection of sewage in the city of Niasser." Semnan, Sixth National Congress of Civil Engineering.
21. Amir Salami, Sara, Alaei, Saeed, (1402), Fuzzy DENAP-Fuzzy TOPSIS-Dual Objective Mathematical Model approach for the problem of green supplier selection and order allocation and its solution with Harmony Search Algorithm, Tehran University Industrial Management Journal
22. Filizadeh, Mohammadreza, Sadeghi, Hassan, 2015, Project management based on multi-criteria decision-making process, Master of Management Thesis, Birjand University
23. Rafezi, Zohra, Hadi Nejaad, Farhad, Kazem, Saeed, Mirzazadeh, Fereshte, Valipour, Habib, 2013, the second social psychology congress of Iran
24. Asgharpour, Mohammad Javad, 2003, Group decision-making and game theory with an operations research approach, first chapter, Tehran, Tehran University Publications.

25. Hatem, Nahid, Torani, Sogand, 2014, Application of multi-criteria decision making model in measuring hospital efficiency, scientific journal of Qazvin University of Medical Sciences
26. Safari, Mehdi, Islamzadeh, Omid, 2015, selection and test of bankruptcy model with multi-criteria decision criteria, the second international conference of new ideas in management, economics and accounting, Singapore

- Colson G, Bruyn CD (1989) "Models and methods in multiple objectives decision making" Math. Comput.Modelling 1989;12: PP.1201–11.
- Drew D, Skitmore M, Po Lo H (2001) "the Effect of Client and Type and Size of Construction Work on a Contractor’s Bidding Strategy" Building and Environment 2001;36(3):393–406
- Guitoun A, Martel JM (1998) "Tentative Guidelines to Help Choosing an Appropriate MCDA Method" European Journal of Operational Research 1998; 109: PP.501–21