Scholarly Publisher
RS Global Sp. z O.O.
ISNI: 0000 0004 8495 2390

Dolna 17, Warsaw, Poland 00-773
Tel: +48 226 0 227 03
Email: editorial_office@rsglobal.pl

JOURNAL	International Academy Journal Web of Scholar
p-ISSN	2518-167X
e-ISSN	2518-1688
PUBLISHER	RS Global Sp. z O.O., Poland

ARTICLE TITLE	SOLUTION OF A MULTI-CRITERIA DECISION-MAKING PROBLEM ON BASE OF PROMETHEE METHOD
AUTHOR(S)	Salimov Vagif Hasan Oglu
ARTICLE INFO	Salimov Vagif Hasan Oglu. (2020) Solution of a Multi-Criteria Decision-Making Problem on Base of Promethee Method. International Academy Journal Web of Scholar. 7(49). doi: 10.31435/rsglobal_wos/30092020/7182
DOI	https://doi.org/10.31435/rsglobal_wos/30092020/7182
RECEIVED	16 July 2020
ACCEPTED	24 August 2020
PUBLISHED	31 August 2020
LICENSE	This work is licensed under a **Creative Commons Attribution 4.0 International License.**

SOLUTION OF A MULTI-CRITERIA DECISION-MAKING PROBLEM ON BASE OF PROMETHEE METHOD

Salimov Vagif Hasan Oglu,
Ph.D., Azerbaijan Republic, Baku, Azerbaijan state oil and industry university,
assoc. prof. of "Computer engineering" department

DOI: https://doi.org/10.31435/rsglobal_wos/30092020/7182

ARTICLE INFO

Received: 16 July 2020
Accepted: 24 August 2020
Published: 31 August 2020

KEYWORDS

Multi criteria decision making,
aggregation,
preference,
difference,
indifference,
rank.

ABSTRACT

Multi criteria decision making problem was considered. Review of existing multi criteria decision making methods was presented. Methods of solving this problem can be divided into two large groups: methods using the aggregation of all alternatives according to all criteria and the solution of the obtained one-criterion problem, the second group is associated with the procedure of pairwise comparisons. Promethee method have been considered with details. This method is based on the pairwise comparison of alternatives and specific aggregation procedures. The preference function are considered for minimization and maximization cases. As practice problem the job selection is considered. Three important criteria are used: salary, time, risk. The results of all computations are presented.

Citation: Salimov Vagif Hasan Oglu. (2020) Solution of a Multi-Criteria Decision-Making Problem on Base of Promethee Method. *International Academy Journal Web of Scholar.* 7(49). doi: 10.31435/rsglobal_wos/30092020/7182

Introduction. The problem of multi-criteria decision-making (MCDM) is one of the actual one in the theory of decision-making /1-2/. From a mathematical point of view, it belongs to the class of vector optimization problems. The criteria can be divided into two groups: the criteria for which the maximum value is optimal and the criteria for which the minimum value is optimal. MCDM problems can be solved to within a plurality of non-dominated set of alternatives or set of compromises. Obtaining a single solution can be realized only on the basis of some compromise scheme that reflects the preferences of the decision maker (DM). Methods for solving this problem can be divided into two large groups: methods using the aggregation of all alternatives according to all criteria and the solution of the obtained one-criterion problem, the second group is associated with the procedure of pairwise comparisons and stepwise aggregation. In the first group include the methods: weighted average sum, weighted product and their various modifications /3-4/, in a second group are − Analytical Hierarchy Process (AHP), Elimination and Choice Translating Reality (ELECTRE), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Preference Ranking Organization Method (PROMETHEE) /5-20/. The work /3/ provides information on the popularity of various methods of multi-criteria decision-making.

The description of method.

Consider the algorithm of the PROMETHEE method

Method PROMETHEE developed by J.P. Brans and B. Mareschal in 1982 and has been further improved. This method uses a special heuristic scheme for determining pairwise preferences between alternatives.

As known, MCDM problem is specified by a matrix of evaluating alternatives by criteria.

	C_1	C_2	C_3	C_j	C_m
A_1	U_{11}				
A_2			U_{23}		
A_i				U_{ij}	
A_n	U_{m1}				U_{nm}

Here is

C_j − criterion for evaluating alternatives

A_i − alternative

U_{ij} − assessment of the alternative A_i by criterion C_j

First of all, for each criterion, the difference between the estimates of all pairs of alternatives a and b is calculated

$$d = a - b$$

The distance is a measure of the dominance (preference) of one alternative over another. Than more distance, than more dominance, if distance close to zero, then there is no dominance. Distances are calculated according to all criteria. For each criterion, we have a distance matrix (Table 1).

Distance matrix Table 1

	A_1	A_2	A_3	A_j	A_n
A_1	d_{11}				
A_2			d_{23}		
A_i				d_{ij}	
A_n	d_{m1}				d_{nn}

For more convenient normalized measure preferences first introduced a special preference function $P(d)$. This function should be monotonic and is determined for each criterion individually. For the maximum criteria, the function must be monotonically non-decreasing, for the minimum criteria, it must be monotonically non-increasing.

Preference function must have the following properties:

$0 \le P_j(a,b) \le 1$

$P(a,b) = 0,\ if\ d \le 0,$ no preference or indifference

$P(a,b) \approx 0,\ if\ \ d > 0,$ weak preference

$P(a,b) \approx 1, if\ d \gg 0,$ strong preference

$P(a,b) = 1, if\ d \ggg 0,$ absolute preference

For criteria where the maximum of the function is optimal, it will have the form

$$P(d) = \begin{cases} 0 & d \le q \\ \frac{d-q}{p-q} & q < d \le p \\ 1 & d > p \end{cases} \quad (1)$$

For the criteria, where it is optimal at minimum, the function will have the form

$$(d) = \begin{cases} 1 & d < p \\ 1 - \frac{d-p}{q-p} & q < d \le p \\ 0 & d \ge q \end{cases} \quad (2)$$

As a rule, this function is set of parametric and depends on two parameters q и p.

The parameter q defines the level of indifference, and the parameter p sets the preference threshold.

If the distance between the two alternatives is $a\ and\ b$ less than p, then this difference is considered insignificant and the preference for the alternative is 0.

If the distance between two alternatives $a\ and\ b$ is greater than p, then this difference is considered significant and there is a strong preference for the alternative $a\ over\ b$, $P(a,b)$ i.e. is equal to 1. In the interval $q \le d < p$ there is a weak preference.

Various preference functions have been developed. There is no formal criterion for selection values, they are selected from the context of the corresponding criteria. For example, parameters can be selected using the formulas: q = 0.05 (maxU - minU), p = 0.2 (maxU - minU) for maximization criteria, and q = 0.05 (minU - maxU), p = 0.2 (minU - maxU) for the minimization criteria.

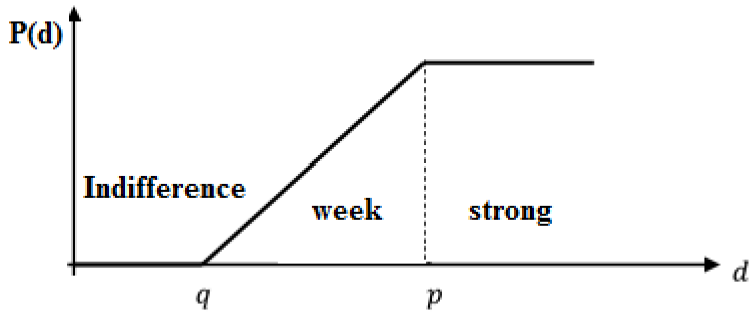

Fig.1. The preference function for the maximization criteria

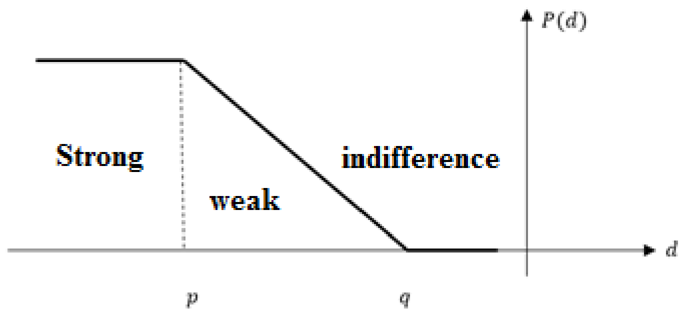

Fig.2. The preference function for minimization criteria

In the general case, each criterion has its own preference function and its own parameters p and q.

For each criterion and for each distance matrix, preference matrices P_j(d). are calculated. As a result, we obtain preference matrices for any criteria. Based on the preference matrices, the matrix of aggregated indices $\pi(a,b)$ is calculated for all criteria

For this, the weighting coefficients W_j of the criteria are set

$$\pi(a,b) = \sum_{j=1}^{m} W_j P_j(a,b) \text{ where } \sum_{j=1}^{m} W_j = 1$$

Next, global estimates are calculated (preference coefficients of each alternative) coefficients of positive $\Phi^+(a)$ and negative $\Phi^-(a)$ preferences. The positive preference coefficients are calculated as the sum of the values of the preference index matrix by rows, and the negative preference coefficients are calculated as the sum of the columns.

$$\Phi^+(a) = \frac{1}{(n-1)} \sum_{b \in A} \pi(a,b)$$

$$\Phi^-(a) = \frac{1}{(n-1)} \sum_{b \in A} \pi(b,a)$$

Next, the total preference function is calculated

$$\Phi(a) = \Phi^+(a) - \Phi^-(a)$$

The alternative with the maximum value is recognized as the best.

3. **Research results.** Consider the problem of selection of a job (job selection). Uses 3 criteria on the basis of which the choice salary (**salary**), time to get to work (**time**), work-related risk (**risk**). There are 5 alternatives, of which the selection of the optimal variant should be made based the PROMETHEE method. Obviously, for the **salary** criterion, the maximum is optimal, for the remaining two criteria, the minimum is optimal. All calculations were performed in MS Excel. The problem is solved in 4 stages:

1. At the first stage, paired distances are calculated for each criterion which form matrices **salary**, **time**, **risk**

	max	min	min
	Salary	Time	Risk
A1	75	60	5
A2	60	50	9
A3	80	80	7
A4	80	70	4
A5	65	60	8

Salary	A1	A2	A3	A4	A5
A1	0	15	-5	-5	10
A2	-15	0	-20	-20	-5
A3	5	20	0	0	15
A4	5	20	0	0	15
A5	-10	5	-15	-15	0

Time	A1	A2	A3	A4	A5
A1	0	10	-20	-10	0
A2	-10	0	-30	-20	-10
A3	20	30	0	10	20
A4	10	20	-10	0	10
A5	0	10	-20	-10	0

Risk	A1	A2	A3	A4	A5
A1	0	-4	-2	1	-3
A2	4	0	2	5	1
A3	2	-2	0	3	-1
A4	-1	-5	-3	0	-4
A5	3	-1	1	4	0

Fig.3. Initial matrix of alternatives and matrices of paired distances

2. For each criterion, based on the context, preference functions and corresponding parameters are determined

	salary	time	risk
q	10	-10	-5
p	20	-30	-1

For the salary criterion, function (1) is used, and for the time and risk criteria, function (2).

Applying these functions to each element of the corresponding matrices, we obtain preference matrices.

	A1	A2	A3	A4	A5
A1		1			1
A2					
A3		1			1
A4		1			1
A5					

	A1	A2	A3	A4	A5
A1			1		
A2			1	1	
A3					
A4					
A5			1		

	A1	A2	A3	A4	A5
A1				1	
A2	1		1	1	1
A3	1			1	
A4					
A5	1		1	1	

Fig. 4. Preference matrices by criteria

3. At this stage, aggregation is performed by criteria into a single matrix of preference indices. For this, weights of the criteria must be specified.

In our case $W_1 = 0.4$ $W_2 = 0.3$ $W_3 = 0.3$. As a result, we have a matrix of aggregated preference indices.

	A1	A2	A3	A4	A5	Φ+		Φ
A1	0	0,4	0,3	0,3	0,4	1,4	0,9	0,5
A2	0,3	0	0,6	0,6	0,3	1,8	1,2	0,6
A3	0,3	0,4	0	0,3	0,4	1,4	1,5	-0
A4	0	0,4	0	0	0,4	0,8	1,5	-1
A5	0,3	0	0,6	0,3	0	1,2	1,5	-0
Φ-	0,9	1,2	1,5	1,5	1,5			

Fig. 5. Aggregated preference matrix, coefficients of the positive, negative preferences and total preferences

4. Computing global scores Φ^{+}, Φ^{-}, Φ

According to the corresponding formulas, the coefficients of positive Φ^{+} and negative Φ^{-} and total Φ preferences are calculated and the optimal alternative is determined, i.e. alternative with the maximum value in this case it will be alternative A2

Conclusions. The article deals with the problem of multi-criteria decision making based on the PROMETHEE method. The classification of methods of multi-criteria decision making is given. The PROMETHEE method is considered in detail. An example of solving the problem of selection a job according to three criteria is given.

REFERENCES

1. C.-L. Hwang, K. Yoon, Multiple Attribute Decision Making: Methods and Applications. New York: Springer- Verlag, 1981
2. V. Belton and T. Stewart, Multiple criteria decision analysis: an integrated approach. Springer Science & Business Media, 2002.
3. A. Mardani, A. Jusoh, Khalil MD Nor, Z. Khalifah, N. Zakwan, A. Valipour Multiple criteria decision-making techniques and their applications - a review of the literature from 2000 to 2014, ISSN: 1331-677X (Print), 2015
4. Chakraborty, S., & Zavadskas, EK Applications of WASPAS method in manufacturing decision making. Informatica, 25 (1), 1-20, 2014
5. Boucher, TO, & MacStravic, E. L. Multi attribute evaluation within a present value framework and its relation to the analytic hierarchy process. The Engineering Economist, 37 (1), 1-32, 1991
6. Taha, RA, & Daim, T. Multi-criteria applications in renewable energy analysis, a literature review. In Research and Technology Management in the Electricity Industry (pp. 17-30). Springer London, 2013
7. Wu, HY, Chen, JK, Chen, IS, & Zhuo, HH Ranking universities based on performance evaluation by a hybrid MCDM model. Measurement, 45 (5), 856-880., 2012
8. Beccali, M., Cellura, M., & Ardente, D. Decision making in energy planning: the ELECTRE multicriteria analysis approach compared to a fuzzy-sets methodology. Energy Conversion and Management, 39 (16-18), 1869-1881, 1998
9. Rogers, M., & Bruen, M. Using ELECTRE III to choose route for Dublin port motorway. Journal of Transportation Engineering, 126 (4), 313-323, 2002
10. Srdjevic, B., & Medeiros, YDP Fuzzy AHP assessment of water management plans. Water Resources Management, 22 (7), 877-894, 2008
11. Meixner, O. Fuzzy AHP group decision analysis and its application for the evaluation of energy sources. In Proceedings of the 10th International Symposium on the Analytic Hierarchy / Network Process, Pittsburgh, PA, USA (Vol. 29), 2009
12. Phanarut Srichetta and Wannasiri Thurachon. Applying fuzzy analytic hierarchy process to evaluate and select product of notebook computers. International Journal of Modeling and Optimization, Vol. 2, No. 2, pp. 168-173, 2012. DOI: 10.7763/IJMO.2012.V2.105.
13. Ayhan, MB A fuzzy AHP approach for supplier selection problem: A case study in a Gear motor company. arXiv preprint arXiv: 1311.2886, 2013
14. Seyedmohammadi, J., Sarmadian, F., Jafarzadeh, A.A., Ghorbani, M.A., & Shahbazi, F. Application of SAW, TOPSIS and fuzzy TOPSIS models in cultivation priority planning for maize, rapeseed and soybean crops. Geoderma, 310:178-190, 2018, https://doi.org/10.1016/j.geoderma.2017.09.012.
15. Boran, F.E., Genç, S., Kurt, M., & Akay, D. A multi-criteria intuitionistic fuzzy group decision making for supplier selection with TOPSIS method. Expert Systems with Applications, 36 (8), 11363-11368, 2009
16. Nydic k, RL, & Hill, RP Using the analytic hierarchy process to structure the supplier selection procedure. International Journal of Purchasing and Materials Management, 28 (2), 31-36, 1992
17. Mary, SASA and Suganya, G. Multi-Criteria Decision Making Using ELECTRE. Ci rcuits and Systems, 7,1008-1020, 2016
18. Mare schal, B., & Mertens, D. BANKS a multicriteria, PROMETHEE-based, decision support system for the evaluation of the international banking sector. Journal of Decision Systems, 1 (2-3), 175-189, 1992
19. Abu- Taleb, MF, & Mareschal, B. Water resources planning in the Middle East: application of the PROMETHEE V multicriteria method. European journal of operational research, 81 (3), 500-511, 1995
20. Goumas, M., & Lygerou, V. An extension of the PROMETHEE method for decision making in fuzzy environment: Ranking of alternative energy exploitation projects. European Journal of Operational Research, 123 (3), 606-613, 2000
21. Dağdeviren, M. Decision making in equipment selection: an integrated approach with AHP and PROMETHEE. Journal of intelligent manufacturing, 19 (4), 397-406, 2008
22. Brans, JP, & Vincke, P. Note— A Preference Ranking Organization Method: (The PROMETHEE Method for Multiple Criteria Decision-Making). Management science, 31 (6), 647-656, 1985