

## MULTI-CRITERIA DECISION IN THE CHOICE OF ADVERTISING TOOLS

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**Abstract.** *In this paper we present the basic theoretical settings of the PROMETHEE method, which has been successfully applied in the process of making decision in multi-criteria decision-making. The illustration of the practical application of this method to a hypothetical example of item-selection in the branding of a new product is done. Using the calculations obtained by the Decision Lab Program, the analysis of the achieved results is done and the decision about the most effective branding item is made.*

**Key words:** *Decision-making, Method Application, Multi-criteria Decision-making*

### 1. INTRODUCTION

Due to the development of decision-making science, many methods have been developed which have enable problem-resolution by means of mathematical methods. Due to the development of computer programs, many of these methods are available in the electronic version also, what assuages the process of the decision-making. One of the possible methods is the PROMETHEE method I-IV, which belongs to the methods of multi-attributes decisions. The basic concept in the terminology of the multivariate decision-making is the attribute, which has the task to enable the evaluation item at the level of one criterion. Every alternative, by the rule, characterizes a number of attributes, which have been chosen on the basis of the chosen criteria by the decision maker [1]. The attributes differ by themselves in many features, while the most important differences are: precision at which they can be measured, and the direction of the correlation between the values of attributes and the usefulness the attributes provide.

## 2. THEORETICAL BASE OF THE PROMETHEE-GAIA METHODS

Most of the economic, political, financial and industrial problems are multi-criteria ones. The issue about the choice and ranking of alternatives is not easy, at all, to solve. In particular, there is no optimal solution – neither alternative is the best for every criterion. No one buys a car only because of the price, conformity or quality -- the performance and the prestige are also considered [2]. On the other hand, we do not react in the same way while taking into consideration some criterion. The choice is subjected to the taste of the individuals. Better quality implies a higher price. A compromise should be considered, but it should be the most beneficial compromise. Recently, some decision aid methods have been developed, that is, decision support systems [3], whose role is to help the decision maker, in the process of selecting the most optimal alternative.

PROMETHEE-GAIA methodology is known as the most efficient and the easiest to use among the methodologies in the field of multi-criteria decisions [4-8]. Also, the newly-developed software, available to the individuals, is called the Decision Lab [9]. The software has been developed together with the Canadian company Visual Decision, as a support in decision-making, and is applicable to all problems. This software treats matrices similarly as is given in the Table 1 [1] where  $A_1, A_2, A_3, \dots, A_m$  are  $m$ -potential alternatives, and  $X_1, X_2, X_3, \dots, X_k$  are  $k$ -criteria. All variables  $X_j(A_i)$  must be real numbers.

Table 1 Initial Data Contained in the Evolution Table

Alternative	Attribute (criterion)					
	$X_1$	$X_2$	...	$X_j$	...	$X_k$
$A_1$	$x_{11}$	$x_{12}$	...	$x_{1j}$	...	$x_{1k}$
$A_2$	$x_{21}$	$x_{22}$	...	$x_{2j}$	...	$x_{2k}$
.	...	...	...	...	...	...
$A_i$	$x_{i1}$	$x_{i2}$	...	$x_{ij}$	...	$x_{ik}$
.	...	...	...	...	...	...
$A_m$	$x_{m1}$	$x_{m2}$	...	$x_{mj}$	...	$x_{mk}$

PROMETHEE methods need additional information. For every criterion the specific function of preferences must be defined. PROMETHEE & GAIA calculate positive and negative flows of preferences for every alternative. The positive flow shows the quantity in which one alternative dominates over the others, while the negative flow shows their weaknesses comparing to the other alternatives.

PROMETHEE I (partial ranking) and PROMETHEE II (complete ranking) methods are developed by Brans, [4]. Both the methods help the decision maker to make the final selection between the best compromises.

In the same year, a couple of practical methods were presented by Davignona [10]. Some years later, Brans and Mareschal developed PROMETHEE III and PROMETHEE IV methods [8]. The same authors in 1988 suggested the visual interactive modulations GAIA that offered the graphical interpretation of the PROMETHEE method. Further, in 1992 and 1994 Brans and Mareschal suggested two supplements more: PROMETHEE V and PROMETHEE VI [11-12].

Many successful forms of this method are also noticed. PROMETHEE-GAIA method has found its application in banking, looking for industrial locations, investments, medicine, tourism [13-15]. Success of these methods is due to the mathematical properties and specific easiness of their use.

### 3. PRACTICAL EXAMPLE OF THE APPLICATION OF THE PROMETHEE-GAIA METHOD

A practical application of PROMETHEE-GAIA method is shown in the example of one bicycle-manufacturing company which intends to advertise its products. The final considerations have narrowed down to six marketing actions, namely advertising in international newspapers, TV advertising, mail advertising, and poster advertising [16].

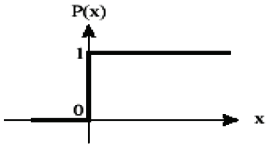
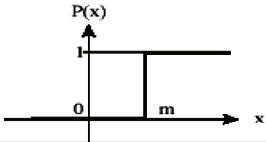
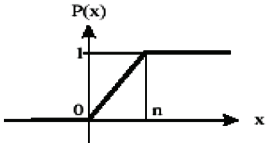
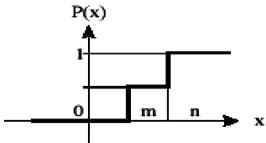
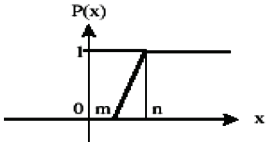
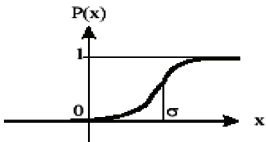
The costs are given in thousands of euros, the target population in tens of thousands viewers (readers). The electivity is expressed in the scale of 0-100. Some criterions are minimized (costs, employees) while some other criterions are maximized (market, time of endurance, effectiveness).

Table 2 Initial Data for the Given Decision Problem in the Evaluation Table

Criterion	C1	C2	C3	C4	C5
	Cost	Market	Endurance	Effectiveness	Employees
Min/max	min	max	Max	max	min
International Newspapers	50	650	28	25	4
Poster	40	620	20	55	2
Mail	90	750	60	35	3
TV	65	900	30	75	6
Weight Coefficient	0.12	0.40	0.12	0.22	0.14

All the criteria are assigned to the common preference function, that is, the common criterion (type I) according to Table 3, according to Ref. [4], [17]. The decision maker also gave the appropriate weights to all the criteria, as presented in Table 2 (weight coefficients).

Table 3 Types of General Criteria

Funkcija preferencije P(x)	Vrsta opšteg kriterijuma	
	Tip I: Običan kriterijum $P(x) = \begin{cases} 0, & x \leq 0 \\ 1, & x > 0 \end{cases}$	-
	Tip II: Kvazi kriterijum $P(x) = \begin{cases} 0, & x \leq m \\ 1, & x > m \end{cases}$	m
	Tip III: Kriterijum sa linearnom preferencijom $P(x) = \begin{cases} 0, & x < 0 \\ x/n, & 0 \leq x \leq n \\ 1, & x > n \end{cases}$	n
	Tip IV: Nivo kriterijum $P(x) = \begin{cases} 0, & x \leq m \\ 1/2, & m < x < n \\ 1, & x \geq n \end{cases}$	m, n
	Tip V: Kriterijum linearne preferencije sa područjem indiferentnosti $P(x) = \begin{cases} 0, & x \leq m \\ \frac{x-m}{n-m}, & m < x \leq n \\ 1, & x > n \end{cases}$	m, n
	Tip VI: Gaussov kriterijum $P(x) = 1 - e^{-\frac{x^2}{2\sigma^2}}$	σ

### 3.1. PROMETHEE and GAIA Analysis

For the computation in the given example The Decision Lab Software [9] has been used, which can graphically represent the results of the ranking of the alternatives. First, in Fig. 1 the initial tabled data in that software is given.

Unit	Troškovi	Tržište	Trajanje	Efikasnost	Zaposleni
	min	max	mah	max	min
Intern. novine	50.0000	650.0000	28.0000	25.0000	4.0000
Posterom	40.0000	620.0000	20.0000	55.0000	2.0000
Postom	90.0000	750.0000	60.0000	35.0000	3.0000
Tv reklama	65.0000	900.0000	30.0000	75.0000	6.0000

Fig. 1 Initial Data for Alternatives and Criteria

According to the evaluated positive (input) and negative (output) streams of preferences, Fig 2, the partial ranking according to PROMETHEE I method has been performed.

	$\Phi^+$	$\Phi^-$	$\Phi$
Intern. novine	0.3000	0.7000	-0.4000
Posterom	0.4067	0.5933	-0.1867
Postom	0.5533	0.4467	0.1067
Tv reklama	0.7400	0.2600	0.4800

Fig. 2 Positive (input) and Negative (output) Streams of Preferences

The Program Decision Lab graphically presents the results in Fig. 3. It is obvious from the graph that the alternative of TV advertisements dominates over the other alternatives. PROMETHEE I does not compare the conflicting actions.

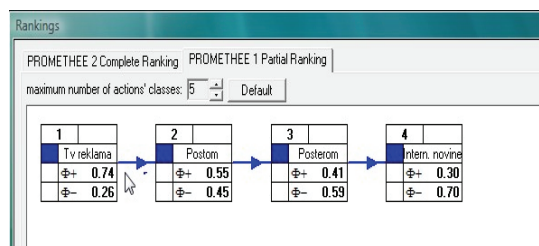


Fig. 3 PROMETHEE I Ranking

PROMETHEE II method provides the decision holder with the ability of the complete ranking of alternatives as shown in Fig 4. From what is given in the figure, it can be concluded that the complete hierarchy of the alternatives is the following: TV advertisement, Mail, Poster, International Newspapers. Both the methods give the strong support of the decision holder in the process of the problem resolving.

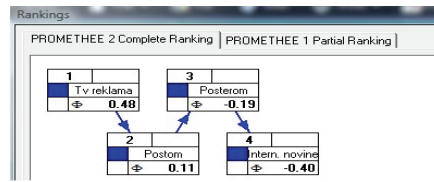


Fig. 4 PROMETHEE II Ranking

It is evident that PROMETHEE I and PROMETHEE II method perform the ranking according to the assigned weighted coefficients. The special option of the software called THE WALKING WEIGHTS enables the initial weights to be modified and the resulting modifications during ranking to be traced by the aid of the PROMETHEE II method in Fig. 5. In this way, the decision holder can simply do the analysis of the sensibility of the obtained results.

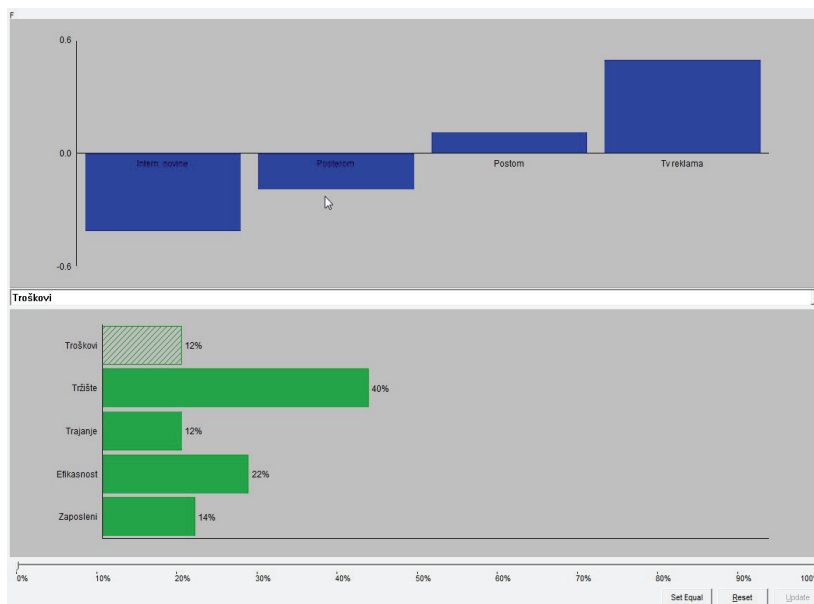


Fig. 5 WALKING WEIGHTS-option Used for Sensibility Analysis

The graphical analysis of the obtained results can also be seen in the Fig. 6.

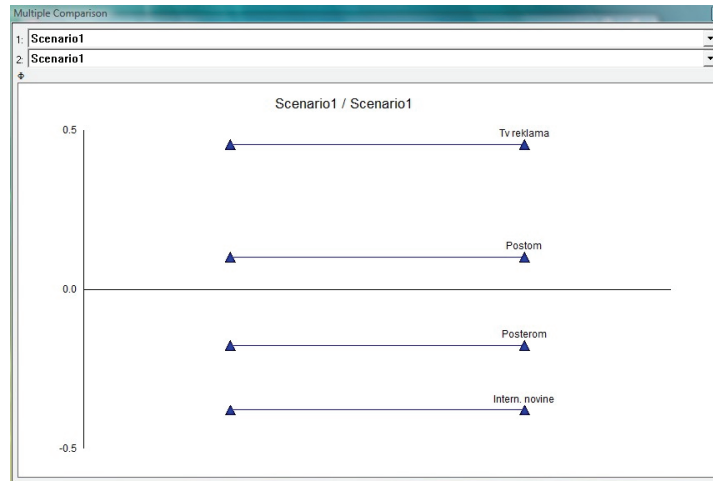


Fig. 6 Graphical Ranking of the Alternatives (According to the Obtained Results)

The information about the complicated decision problem, which has  $k$  criteria, can be represented in the  $k$ -dimensional space. GAUA plane represents the plane obtained by the projection of the total information in 2-dimensional space. In GAIA plane, the alternatives are represented by triangles, and criteria by the axes. The conflict characteristics of the criteria are clearly represented in the diagram; the conflict criteria are oriented in the opposite directions, while the criteria, which have the similar preferences, are oriented in the same direction. In the following example we see that the length and costs represent mutually conflicting criteria Fig. 7. Also, it is able clearly to grade the quality of the alternatives according to the given criterion. It is obvious then that the alternative of the TV advertisement is especially good comparing to the criteria of effectiveness and targeting market, the alternative of the poster advertisement comparing to the expenses, etc. in Fig. 4.

As an appendix to the representation of alternatives and criteria, the projection of the weighted vectors in GAIA plane has the corresponding  $P_i$  vector, which shows the direction of the compromise results. In this way, the decision holder is enabled to decide upon the choice of alternatives by himself. If the weighted coefficients are changed the configuration of the alternatives and criteria is the same, while the direction of the  $P_i$  vector axis changes. If the  $P_i$  vector is longer, the decision axis has more power, that is, the decision holder is provided with a greater number of solutions. If the  $P_i$  vector is shorter, then the decision axis is poorer in the number of solutions given to the user, which means that the criteria are very conflicting and the choice of the best compromise is a very difficult problem. The program enables the usage of the weighted vector as a decision stick for the sake of an easier orientation of the decisions in the plane.

PROMETHEE decision stick and PROMETHEE decision axis enable the quality analysis of the sensitivity of the results. Before the choice of the best compromise, the user is suggested the simulation of the different weighted coefficients -- in any case the situation can be easily validated in the GAIA plane, the suggested alternatives are located in the direction of the decision axis. If the alternatives and criterions stay the same as the

PROMETHEE stick decision moves, then the analysis of the sensibility is very clear and easy for resilience and choice of the best compromise.

According to the position of the Pi vector in GAIA plane we can conclude that the best alternative is TV advertisement (advertising via Television), what affirms the choice with the help of PROMETHEE I PROMETHEE II methods.

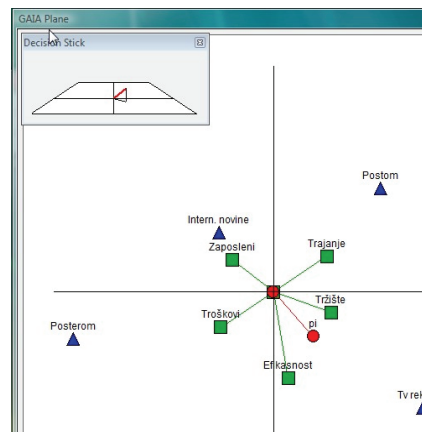


Fig. 7 GAIA plane and Decision Stick for the Given Problem

#### 4. CONCLUSION

In this paper, some theoretical settings of the PROMETHEE methods are presented, as well as their application, which has been illustrated by a hypothetical example of the choice, that is, by ranking of the advertising tools of the mentioned product [21]. The application of the above-mentioned methods significantly simplifies the usage of the software Decision Lab [9], whose help, in a very simple and fast way, approaches the final results and enables descriptive representation of the obtained results using a graphical way of representation. And besides a high quality, it should be emphasized that successfulness of the application of the PROMETHEE methods in the decision process depends, to a large extent, on the following factors:

- possibility and the experience of the decision holder that his own preference, among all options, expresses at the interval scale
- the decision holder is ensured that in the process of the decision-making he wants to take into the consideration all relative criteria and he is aware that the obtained solution will represent the best compromise among all of the analyzed criteria.

If the previous conditions are satisfied then PROMETHEE I and II methods become the tools in the hands of the decision holder which enable the powerful support in the process of resolving complex problems of the multi-criteria decision analysis [17, 18, 19, 20].



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## **VIŠEKRITERIJUMSKO ODLUČIVANJE PRI IZBORU SREDSTVA REKLAMIRANJA**

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*U radu su date osnovne teorijske postavke PROMETHEE metode, koja ima vrlo uspešnu primenu u procesu donošenja odluka kod višekriterijumskog odlučivanja. Izvršena je ilustracija praktične primene ove metode na hipotetičkom primeru izbora sredstva reklamiranja novog proizvoda. Proračun je izveden primenom Decision Lab programa na osnovu čega je izvršena analiza dobijenih rezultata i doneta odluka o najefikasnijem sredstvu reklamiranja.*

*Ključne reči: donošenje odluke, primena metode, višekriterijumsko odlučivanje*