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Multicriteria Analysis of Economic Activity for Two Groups of European Countries by Decision Support System MKA-1*

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Abstract: *This work presents the results obtained from an attempt for multicriteria analysis of the economic activity in 2003 for two groups of European countries: sixteen former socialist countries and sixteen developed European countries. A multicriteria decision support system, developed at the Institute of Information Technologies-BAS, is used. Five macro-economic criteria have been considered in the analysis: GDP per capita; Exports (% of GDP); Imports (% of GDP); Inflation rate (consumer prices); Unemployment rate.*

***Keywords*:** *multicriteria analysis, decision support system.*

Introduction

Multicriteria decision making problems can be divided into two separate classes depending on their formal statement (V i n c k e [17], Y o o n, H w a n g [18]). In the first class a finite number of explicitly set constraints in the form of functions define an infinite number of feasible alternatives. These problems are called continuous multicriteria decision making problems or multicriteria optimization problems. In the second class of problems a finite number of alternatives are explicitly given in a tabular form. These problems are called discrete multicriteria decision making problems or multicriteria analysis problems. The multicriteria analysis problems can be divided into three types: problems of multicriteria choice, problems of multicriteria ranking and problems of multicriteria sorting. Many real life problems in management practice may be formulated as problems of choice, ranking and sorting of resources, strategies, projects, offers, policies, credits, products, innovations, designs, costs, profits, portfo-

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lios, etc. (B r o o k s, K i r k w o o d [5], B e l t o n [2], O l s o n [12], F r e n c h [6], B e i n a t, N i j k a m p [1], H o l b o u r n [8]).

The software systems supporting the solution of multicriteria analysis problems can be divided in two classes – software systems with general purpose and problem-oriented software systems. The general-purpose systems developed (Expert Choice (S a a t y [16]), Web-HIPRE (M u s t a j o k i, H a m a l a i n e n [10]), HIVIEW (P e t e r s o n [14]), ELECTRE III-IV (R o y [15]), PROMCALC and GAIA (B r a n s, M a r e s c h a l [3]), Decision Lab (B r a n s, M a r e s c h a l [4]), VIMDA (K o r h o n e n [9]) realize one or several methods from one and the same group of multicriteria analysis methods. Methods from different groups are usually implemented in the problem-oriented software systems. These systems have simplified interface and are built in other information-control systems. One representative of the problem-oriented systems, called Agland Decision Tool is discussed in P a r s o n s [13].

Three different methods – the weighting method AHP (S a a t y [16]), the out-ranking method PROMETHEE II (B r a n s, M a r e s c h a l [3]) and the interactive method CBIM (N a r u l a et al. [11]) are applied in the general purpose software system MKA-1, developed at the Institute of Information Technologies-BAS (G e n o v a et al. [7]). The interface modules built in the system enable the successful realization of different types of procedures for deriving information by the DM and also for the entry of different types of criteria – quantitative, qualitative and ranking criteria.

The software system MKA-1 has been used in an attempt for multicriteria analysis of the economic activity for two groups of European countries. The results obtained from this analysis are described in the paper.

Problem description

The multicriteria analysis of the economic activity in 2003 of two groups of European countries – sixteen former socialist countries and sixteen developed European countries is made on the basis of data taken from *The World Factbook* site on Central Intelligence Agency (CIA) (**http://www.odci.gov/cia/publications/factbook/**). Five macro-economic criteria have been considered in the analysis: GDP per capita; Exports (% of GDP); Imports (% of GDP); Inflation rate (consumer prices); Unemployment rate.

GDP (Gross Domestic Product) gives the gross domestic product (value of all final goods and services produced within a nation in a given year). It is used for evaluating the percentage value of the Exports and Imports criteria. The criterion "*GDP per capita*" shows GDP on a purchasing power parity basis divided by population as of 1 July for the same year. The criterion "*Exports*" provides the total US dollar amount of exports on an f.o.b. (free on board) basis. This criterion is in billion dollars. To convert it into % of GDP, the Exports value is divided by the GDP value (it is also in billion dollars). The criterion "*Imports*" provides the total US dollar amount of imports on a c.i.f. (cost, insurance, and freight) of f.o.b. (free on board) basis. To convert it into % of GDP then the Imports value is divided by the GDP value. The criterion "*Inflation rate*" furnishes the annual percent change in consumer prices compared to the previous year consumer prices. The criterion "*Unemployment rate*" contains the percent of the labor force that is without jobs. Substantial underemployment might be

noted. All criteria are quantitative criteria. The first two of them are for maximization and the other three criteria are for minimization.

The following former socialist countries have been taken into account for the analysis: Poland, Czech Republic, Slovakia, Hungary, Slovenia, Bulgaria, Latvia, Estonia, Lithuania, Romania, Albania, Ukraine, Belarus, Serbia and Montenegro, Macedonia, Bosnia and Herzegovina. The developed European countries considered are sixteen, being the following: the United Kingdom, Ireland, Finland, Portugal, Spain, Switzerland, Italy, Germany, France, Belgium, Netherlands, Sweden, Denmark, Austria, Norway, Greece.

Problem solving

The multicriteria analysis of the economic activity of the countries discussed is done with the help of two methods, which are implemented in the software system MKA-1. These methods are AHP and PROMETHEE II. They provide a complete ranking of the alternatives starting from the best towards the worst one.

- The basic AHP procedure (S a a t y [16]) consists of the following principles: construction of the hierarchy and priority setting by pair-wise comparison. A decision problem, centered around an overall objective or focus is structured and decomposed into its constituent parts (sub-objectives, attributes, criteria, alternatives, etc.), using a hierarchy. The topmost level is the focus of the problem. The intermediate levels correspond to criteria and sub-criteria, while the lowest level contains the alternatives. Arranging the sub-objectives, attributes, issues and involving stakeholders in a hierarchy provides an overall view of the complex relationships and helps the decision maker (DM) to assess whether the issues in each level are of the same magnitude so that homogenous elements can be accurately compared. An element in a given level does not have to function as an attribute (or criterion) for all the elements in the level below. The relative "priority" given to each element in the hierarchy is determined by pair-wise comparing of the contribution of each element at a lower level in terms of the criteria with which a causal relationship exists. The DM uses a pair-wise comparison mechanism, as the verbal judgements ranging from "equal" to "extreme" correspond to the numerical judgements from 1 up to 9. This procedure is repeated for all subsystems in the hierarchy. The fundamental input to AHP is the DM's answer to a series of questions like "How important is criterion A relative to criterion B?". On the basis of a sequence of such pair-wise comparisons, the relative priorities (weights) are determined, using the eigenvector method. The weights should be seen as the relative contribution of an average score (averaged over all options taken into account) of the elements (of a lower level) to each criterion (of a higher level).

- PROMETHEE II is an outranking method (B r a n s, M a r e s c h a l [4]). The starting point is a data matrix in which the alternatives are evaluated for the different criteria. In the following, the alternatives are compared pair by pair with respect to every single criterion. The results of these comparisons are expressed in a numerical value determined by a Preference function. Multiplying the preferences by the weights

of the criteria and adding the single values, a matrix of global preference of the alternatives is calculated. In this matrix, the sum of the row expresses the strength of an alternative (dominance). The sum of the column expresses to what extent an alternative is dominated by the other ones (subdominance). When the subdominance-value is subtracted from the dominance-value, a linear ranking is obtained. DMs are required to weight indicators and to choose a Preference function. The Preference function translates the difference between the evaluations obtained by two alternatives (a and b) in terms of a particular criterion, into a preference degree, ranging from 0 to 1. For every one of these functions 0, 1 or 2 parameters are given. The indifference threshold defines the size of the difference among the alternatives, at which no preference can be expressed, i.e. appoint the better one. The preference threshold defines the difference between two alternatives, which determines strict preference, i.e. one of them is distinctly better than the other. The value of the Gaussian threshold has to be between the indifference threshold and the preference threshold.

In order to facilitate the selection of a specific Preference function, six basic types have been proposed: Usual criterion, U-shape criterion, V-shape criterion, Level criterion, V-shape criterion with indifference and Gaussian criterion.

Table 1 and Table 2 show the matrices of alternatives for the two groups of countries. The data are for year 2003 and they are taken from *The World Factbook* site on the CIA (**http://www.odci.gov/cia/publications/factbook/**). Table 1 shows the matrix of alternatives for the sixteen former socialist countries (Problem 1).

Table 1

Criterion / Alternatives	**2003**				
	GDP per capita	Exports	Imports	Inflation rate	Unemployment rate
	thousands $	% of GDP	% of GDP	%	%
	max	max	min	min	min
Poland	11.1	15.43	17.07	0.7	20
Czech Republic	15.7	29.73	32.08	0.1	9.9
Slovakia	13.3	31.63	32.52	8.6	15.2
Hungary	13.9	31.34	34.48	4.7	5.9
Slovenia	19	32.33	34	5.6	11.2
Bulgaria	7.6	14.83	19.7	2.3	14.3
Latvia	10.2	14.29	23.34	2.9	8.6
Estonia	12.3	26.45	35.48	1.3	10.1
Lithuania	11.4	26.26	30.59	–1.2	10.3
Romania	7	10.40	13.11	15.3	7.2
Albania	4.5	2.55	11.47	2.4	15.8
Ukraine	5.4	10.83	10.83	5.2	3.7
Belarus	6.1	10.42	12.31	28.2	2.1
Serbia and Montenegro	2.2	11.66	30.67	11.2	34.5
FYR Macedonia*	6.7	12.30	20.81	1.2	36.7
Bosnia and Herzegovina	6.1	17.81	64.38	0.9	40

* The former Yugoslav Republic of Macedonia.

Table 2 shows the matrix of alternatives for the sixteen developed European countries (Problem 2).

Table 2

Criterion / Alternatives	2003				
	GDP per capita	Exports	Imports	Inflation rate	Unemployment rate
	thousands $	% of GDP	% of GDP	%	%
	max	max	min	min	min
United Kingdom	27.7	19.93	23.80	1.4	5
Ireland	29.6	86.46	50.57	3.5	4.7
Finland	27.4	40.58	27.95	0.9	9
Portugal	18	15.93	22.39	3.3	6.4
Spain	22	18.74	23.17	3	11.3
Switzerland	32.7	47.13	43.79	0.6	3.7
Italy	26.7	19.11	18.63	2.7	8.6
Germany	27.6	32.26	27.11	1.1	10.5
France	27.6	22.24	21.82	2.1	9.7
Belgium	29.1	61.03	57.72	1.6	8.1
Netherlands	28.6	57.83	49.73	2.1	5.3
Sweden	26.8	44.56	36.11	1.9	4.9
Denmark	31.1	41.34	35.09	2.1	6.1
Austria	30	36.67	35.84	1.4	4.4
Norway	37.8	45.14	26.96	2.5	4.7
Greece	20	2.90	16.38	3.6	9.4

Solving Problem 1

In order to start each problem, the respective matrix of alternatives is needed and its values are entered in *Initially adding for criteria and alternatives* window of the MKA-1 system (Fig.1). Information of the qualitative and quantitative criteria can be processed as well as the variables that describe the dynamics or some patterns of change.

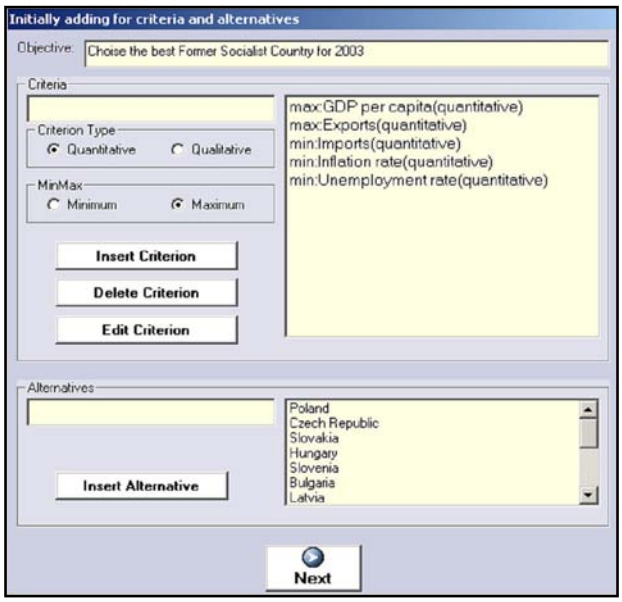


Fig. 1

When all the necessary data is entered, the method must be chosen from the *View* menu or from *Choose method* window (Fig. 2).

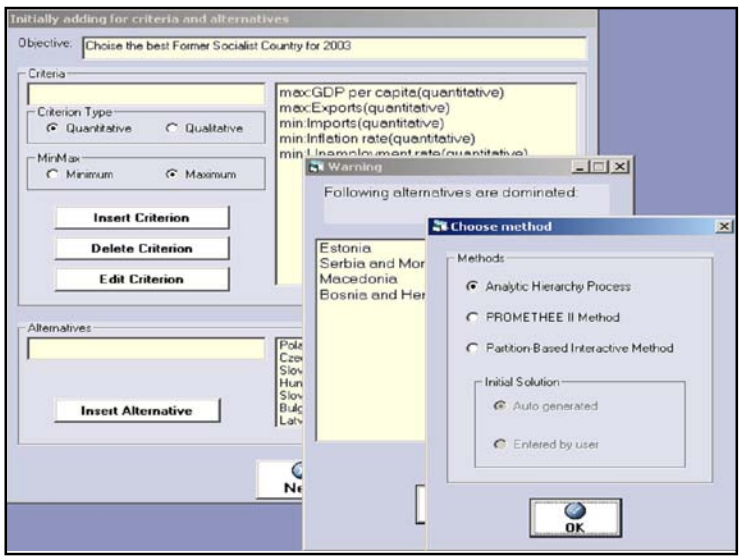


Fig. 2

The dominated alternatives can be seen in the *Warning* window (Fig. 2).

- *Solving Problem 1 with AHP method in the first aspect (with equal weights)*

In this aspect there are no preferences concerning criteria importance and equal weights are chosen for the pair-wise comparison of the criteria (Fig. 3).

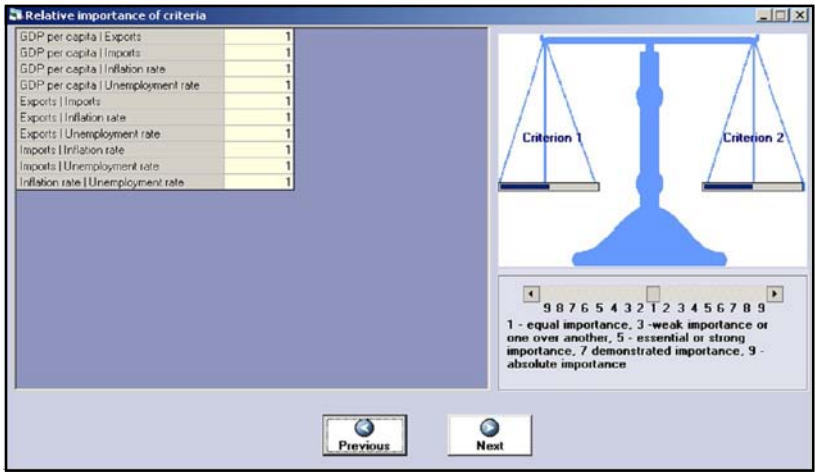


Fig. 3

After giving information of the preferences for each pair of the criteria, the final alternative ranking in a descending order is obtained (diagram of comparison) (Fig. 4).

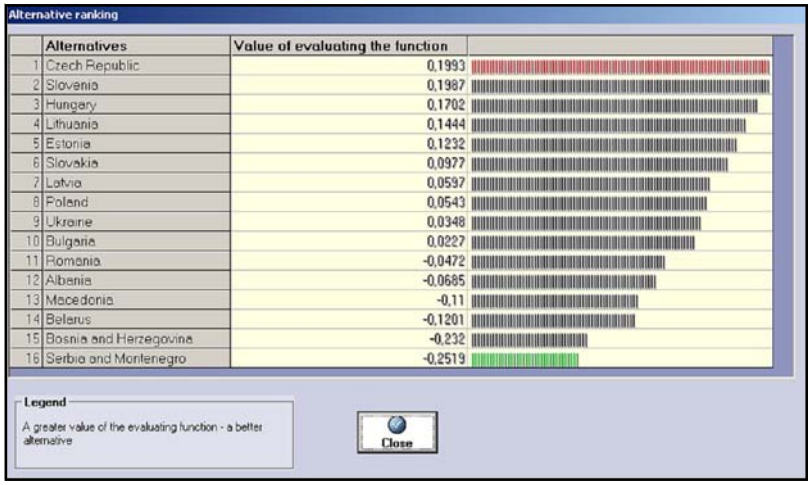


Fig. 4

- *Solving Problem 1 with PROMETHEE II method in the first aspect (with equal weights and Usual criterion as a Preference function)*

The PROMETHEE II method requires additional information for each criterion. In this case equal weights are given for each criterion and Usual criterion is chosen as a Preference function (Fig. 5).

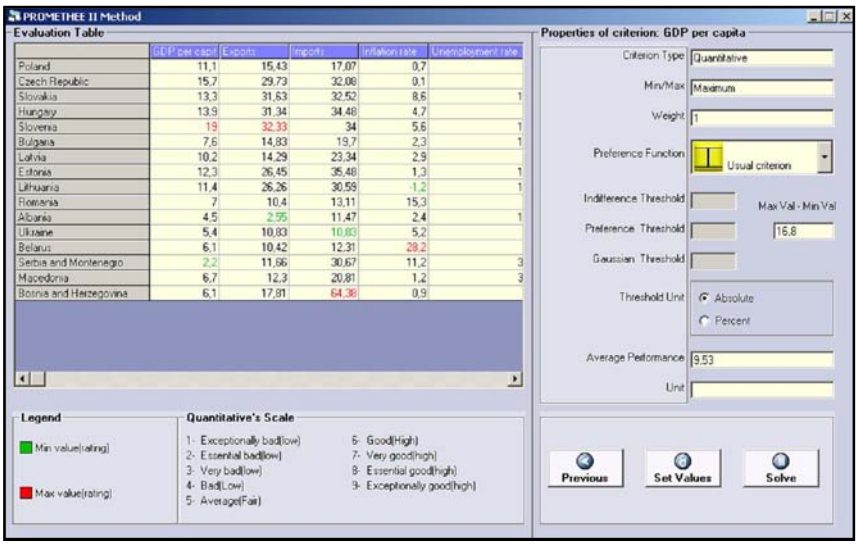


Fig. 5

After providing the complete necessary information for each criterion, the final alternative ranking is obtained in a descending order (Fig. 6).

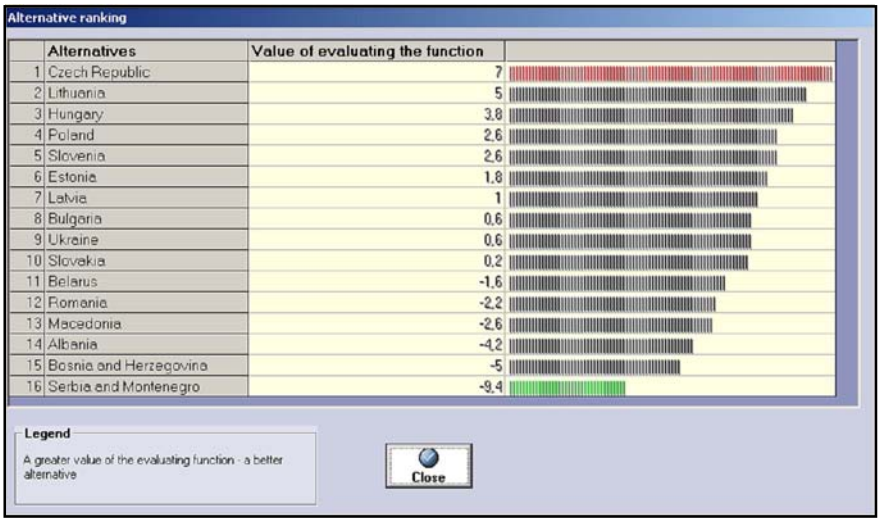


Fig. 6

- *Solving Problem1 with AHP method in the second aspect (with different weights)*

In this aspect there exist preferences of the criteria importance and different weights are chosen for the pair-wise comparison of the criteria. The criterion GDP per capita is selected as the most important criterion. The next in importance criterion is Exports. The criteria Imports, Inflation rate and Unemployment rate are with equal importance (with equal weights). Fig. 7 shows this pair-wise comparison.

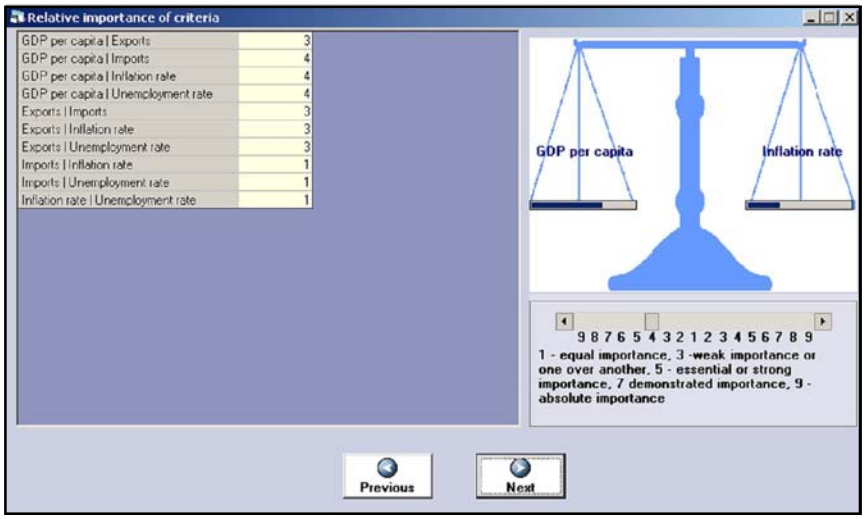


Fig. 7

The final ranking obtained after setting the importance of the criteria, is shown in Fig. 8.

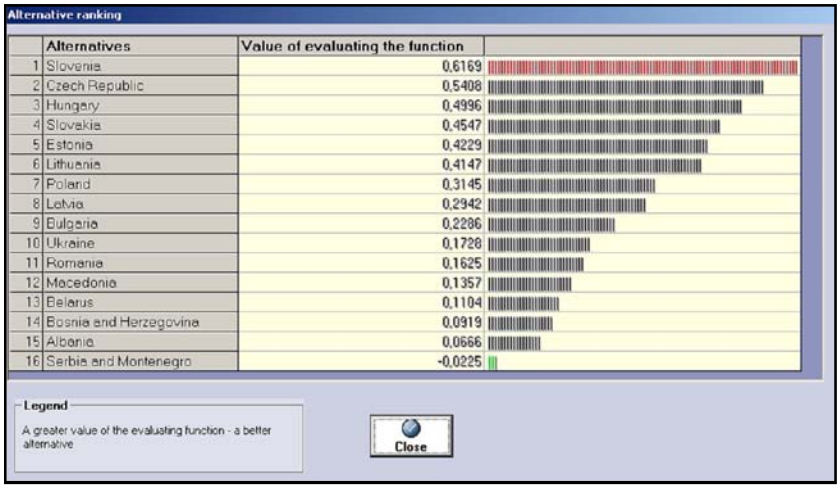


Fig. 8

- *Solving Problem 1 with PROMETHEE II method in the second aspect (with different weights and V-shape criterion with indifference as a Preference function)*

In this aspect different weights are given for each criterion and a V-shape criterion with indifference is chosen as a Preference function (Fig. 9). The greatest weight value is assigned to the criterion GDP per capita. The next in importance criterion is Exports. Equal weights are chosen for the other three criteria.

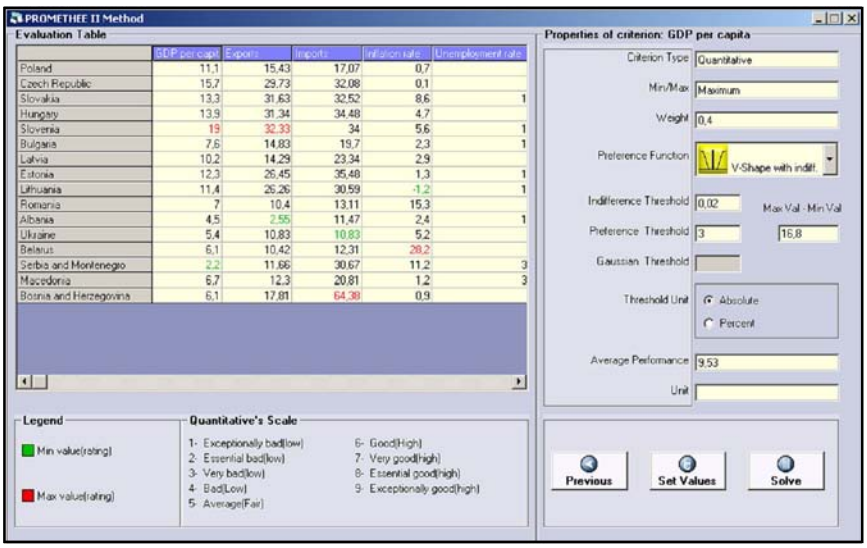


Fig. 9

The final ranking obtained after presenting this information for each criterion, is shown in Fig. 10.

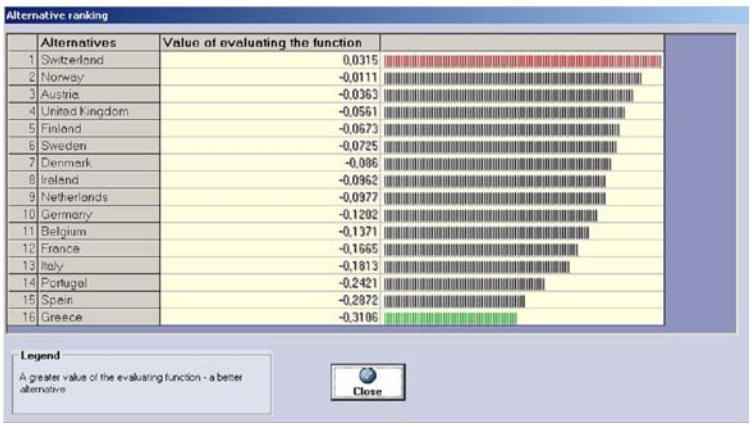
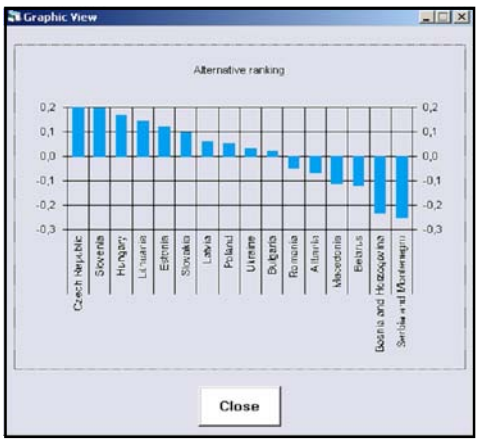
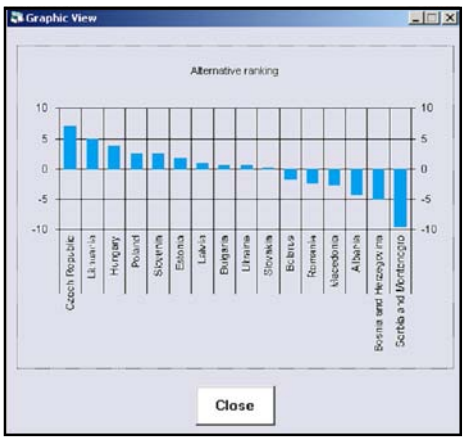


Fig. 10

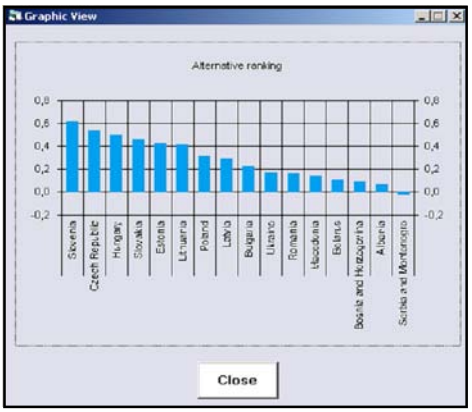
The graphical representation of the results for the first and the second aspects relating to Problem 1 is shown in Fig. 11. This representation can be chosen from the *View* menu.



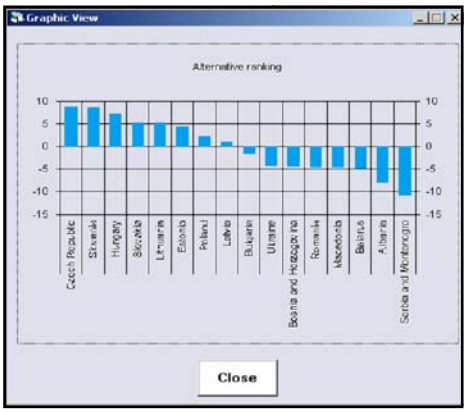
AHP results (in the first aspect)



PROMETHEE II results (in the first aspect)



AHP results (in the second aspect)



PROMETHEE II results (in the second aspect)

Fig. 11

Solving Problem 2

- *Solving Problem 2 with AHP method in the first aspect (with equal weights)*

In this case there are no preferences of criteria importance and equal weights are chosen for the pair-wise comparison of the criteria. The final alternative ranking obtained is shown in Fig. 12:

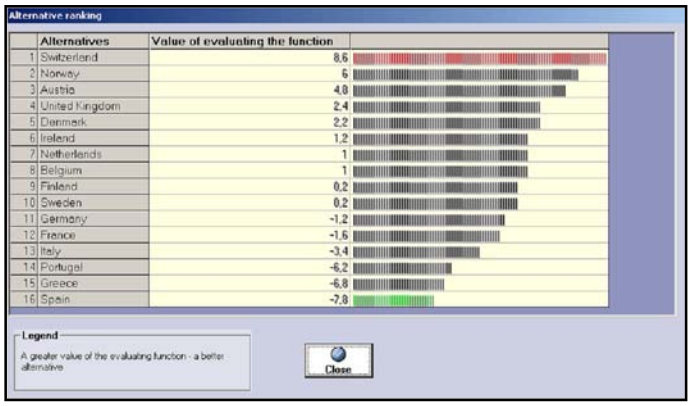


Fig. 12

- *Solving Problem 2 with PROMETHEE II method in the first aspect (with equal weights and Usual criterion as a Preference function)*

Equal weights are given for each criterion and Usual criterion is selected as a Preference function. The final ranking obtained after giving this information for each criterion, is shown in Fig. 13.

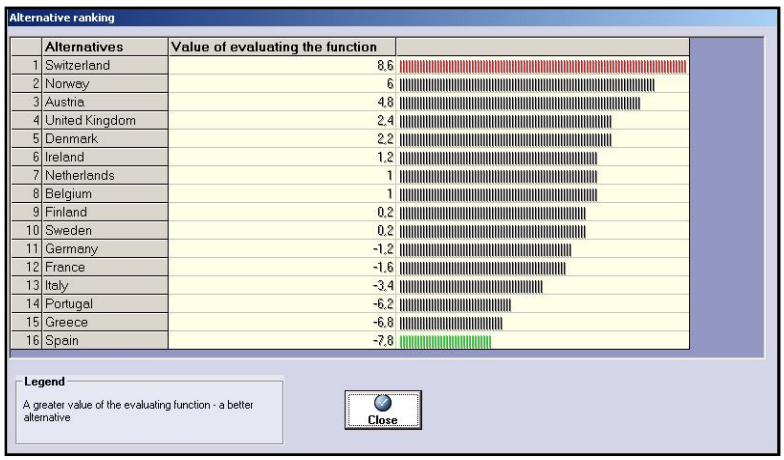


Fig. 13

- *Solving Problem 2 with AHP method in the second aspect (with different weights)*

In this case different weights are set for each criterion with respect to the pair-wise comparison. GDP per capita is chosen as the most important criterion. The next

in importance criterion is Exports. The criteria Imports, Inflation rate and Unemployment rate are with equal importance (with equal weights). This comparison is shown in Fig. 14. The final ranking obtained after this comparison of the criteria, is shown in Fig. 15.

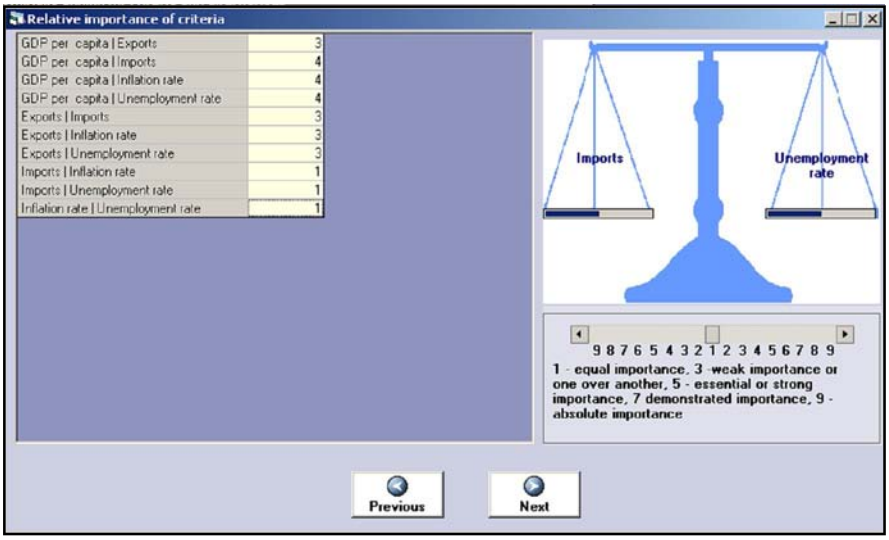


Fig. 14

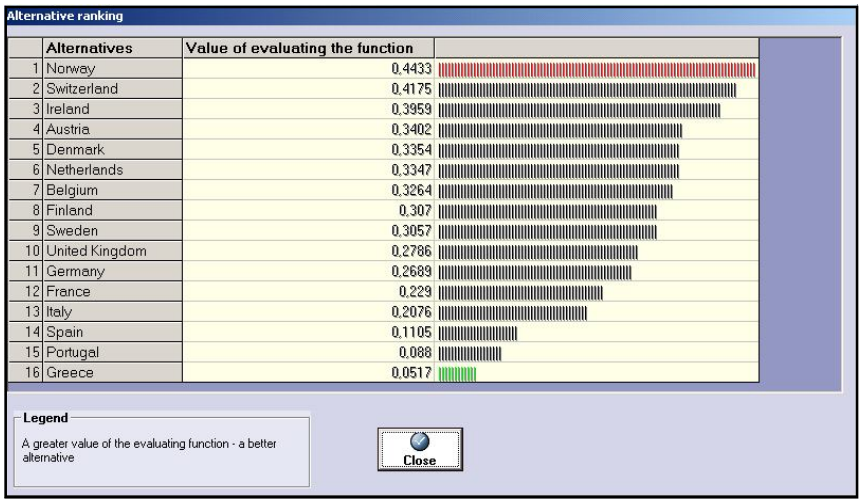


Fig. 15

- *Solving Problem 2 with PROMETHEE II method in the second aspect (with different weights and V-shape criterion with indifference as a Preference function)*

In this aspect different weights are given for each criterion and a V-shape criterion with indifference is selected as a Preference function (Fig. 16). The greatest weight value is given to the criterion GDP per capita. The next in importance criterion is Exports. Equal weights are chosen for the other three criteria.

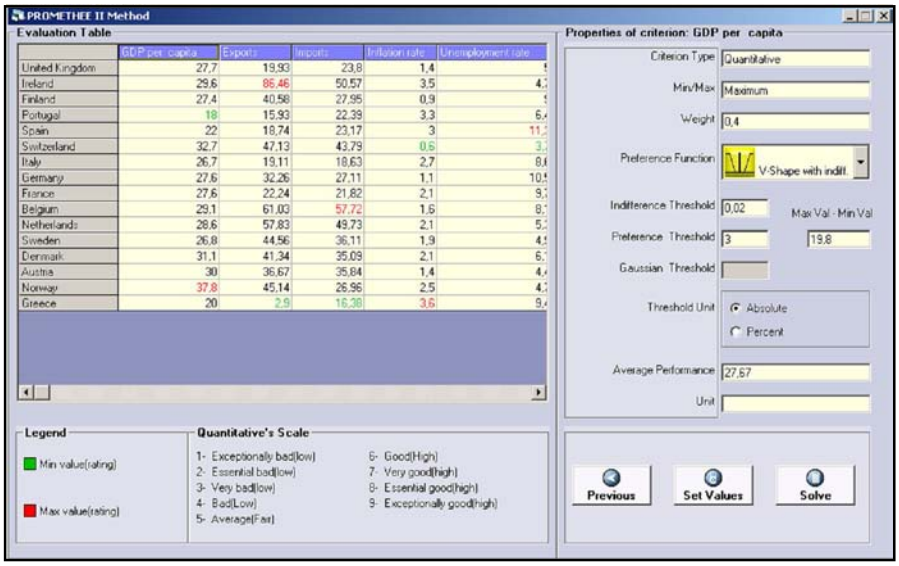


Fig. 16

The final alternative is obtained after providing the necessary information about each criterion (Fig. 17).

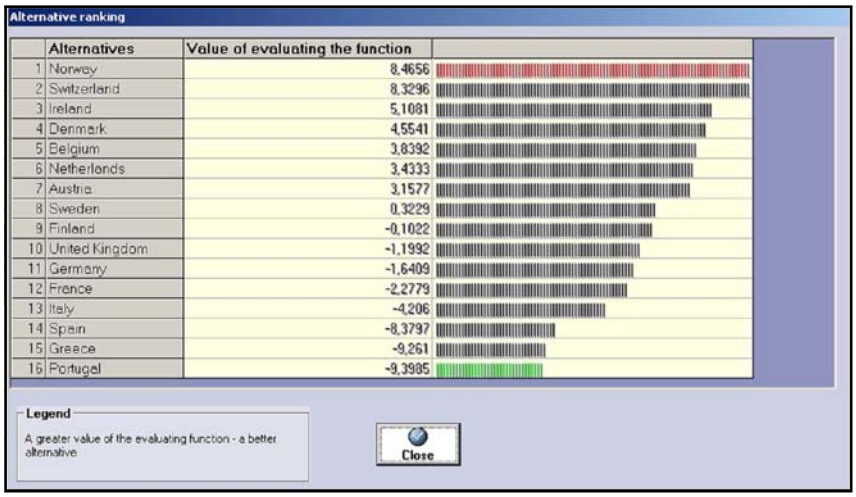
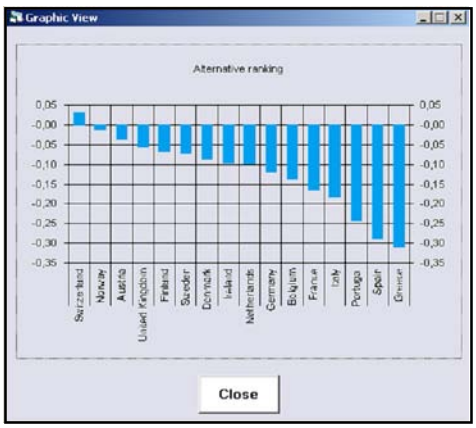
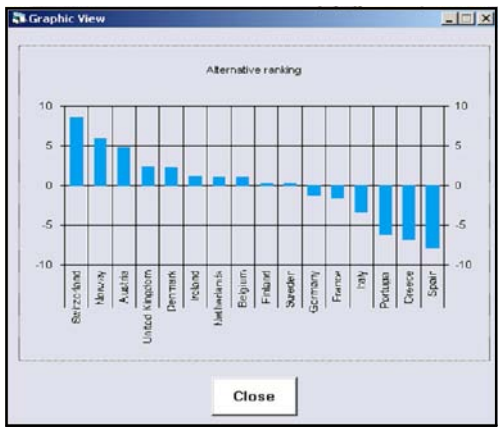


Fig. 17

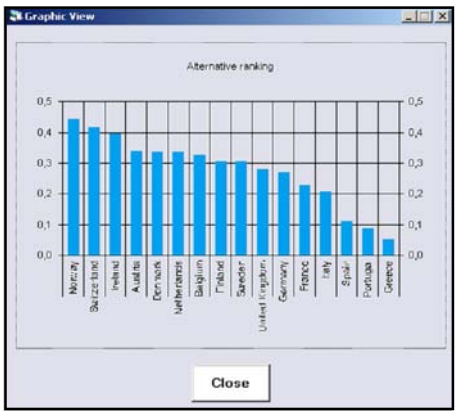
The graphical representation of the results for the first and the second aspects of Problem 2 are shown in Fig. 18.



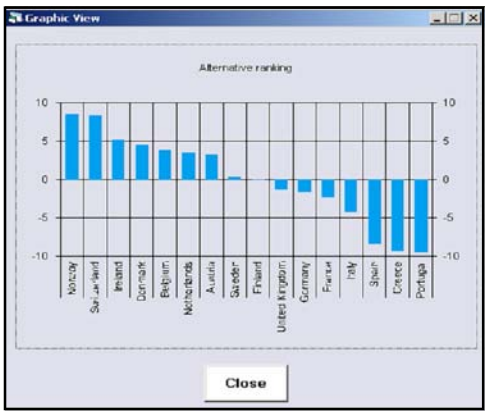
AHP results (in the first aspect)



PROMETHEE II results (in the first aspect)



AHP results (in the second aspect)



PROMETHEE II results (in the second aspect)

Fig. 18

Conclusions regarding the results. Fig. 18 shows that there are some differences in the arrangements, which are obtained. This is due to the methods used as well as to the different weight (importance) given to the separate criteria. For better evaluation it is necessary to use methods like ELECTRE III or PROMETHEE I, in which group arrangements are obtained. The countries possessing near indicators are ranked in groups.

Conclusion

This work presents an attempt for multicriteria analysis of the economic activity in 2003 for two groups of European countries. This analysis is realized with the help of the software system MKA-1. The arrangements obtained can be used to make conclusions about the economic development of each country in comparison with the other countries from the separate groups.

The fluctuations obtained in the arrangements prove that further elaboration of MKA-1 software system is required, including methods for group arrangements (incomplete arrangements).

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