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ON A GROUP MULTICRITERIA METHOD FOR PROJECT EVALUATION

Abstract

Experiences with a real-life case study are presented. The case study deals with the allocation of EU structural funds in the capital region of Mazovia in Poland. A new method in the practice of the funds allocation, supporting multicriteria analysis and selection of projects applying for the funds, has been proposed and used in the study. According to the method, an interactive procedure has been implemented in which a group of experts formulates the multicriteria decision making problem, carries out the multicriteria analysis of the projects, and finally creates a ranking of the projects.

Keywords

Multicriteria analysis, group methods, computer-based support, EU structural funds.

Introduction

The structural funds of the European Union are the financial instruments used to implement the policy for support of multi-dimensional development, enhancement of economic and social cohesion, reducing differences of regional development standards and restructuring and modernizing the economies of those member states whose development level is below the average development level in the European Union.

In the 2007-2013 programming perspective, Poland may take advantage of the support within the framework of the following structural funds: the European Regional Development Fund (ERDF), the European Social Fund (ESF), the Cohesion Fund, the European Agricultural Fund for Rural Development (EAFRD), and the European Fisheries Fund (EFF).

The European Regional Development Fund (ERDF) is meant for financing undertakings in the regions with the development level substantially lagging behind the average for the EU, as well as in the regions with major restructuring activities in industry and employment. The funds are addressed particularly to financing investment in infrastructure and environmental protection, development of small and medium enterprises, creation of new jobs through investment in manufacturing, research and development activities. Potential beneficiaries are territorial self-government units, their unions and associations, entrepreneurs (small and medium), government administration bodies, national and landscape parks, National Forestry and its organizational units, R&D units, (other) units of the public finance sector with legal entity, non-governmental organizations, business support institutions, housing associations and housing cooperatives, as well as water law companies.

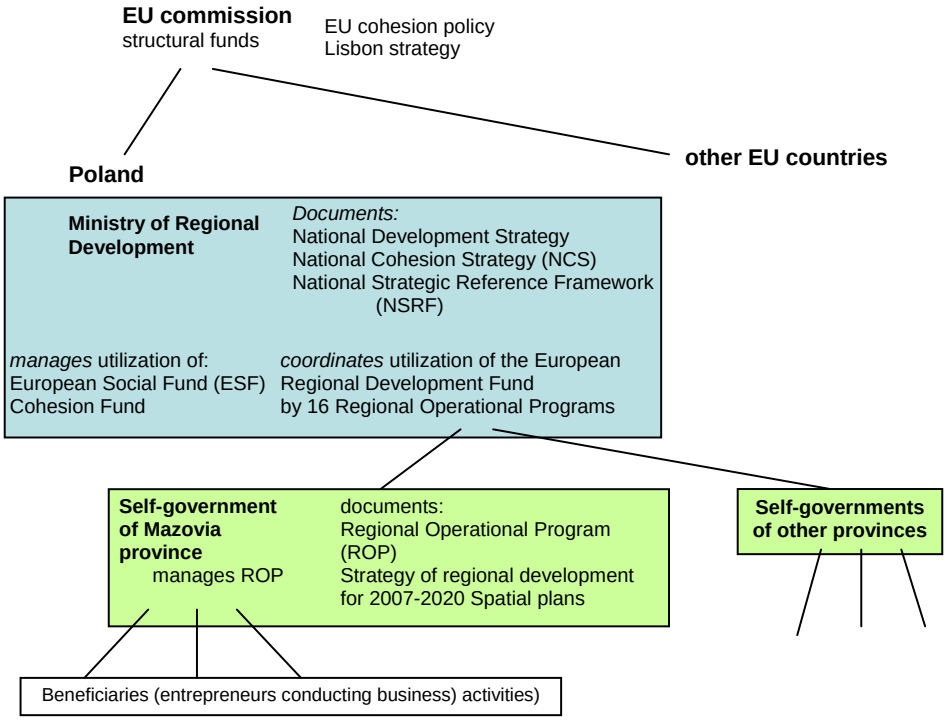

Figure 1. Decision making units allocating and supervising utilization of the EU structural funds

Utilization of the ERDF is coordinated in Poland by the Ministry of Regional Development (see Figure 1). It is done according to the documents such as the National Development Strategy (NDS) for Poland, the National Strategic Reference Framework, and the National Cohesion Strategy adopted by the EU Commission. The Ministry allocates the funds among regions – provinces being administrative units, called voivodships in Poland. The funds are allocated among beneficiaries on the regional level by the self-governments of voivodships within the Regional Operational Programs (ROP), negotiated and approved by the EU Commission. The Ministry, having the consent of the EU Commission, decided that the most important projects for regional development (called key projects) can be submitted and co-financed within the ROP prior to the beginning of standard competitions for other projects.

The paper deals with the Regional Operational Program (ROP) of the capital Mazovian Voivodship for the years 2007-2013. A case study has been organized to support selection of the key projects from a list of projects submitted. The paper describes experiences with the case study.

There exists a rich bibliography on multicriteria analysis, ranking and group methods. Advance ordinal and cardinal approaches have been developed. The respective reviews can be found in [5], [25], [26], [29]. A proposal including application of the outranking method for ordering projects is given by Górecka [4]. On the other hand, in the practice of the UE funds allocation, we deal with hundreds of projects applying, a limited number of experts assessing the projects and very limited time for the assessment and selection process. The experts – assessors obtain evaluation sheets with predefined criteria and propose values for the criteria within given ranges of points. Usually, different experts can understand the criteria in different ways. Finally, the classical weight method is still used to assess the projects. This case study has been organized with the idea that the experts should be involved in the whole MCDM process starting from its formulation. A relatively simple evaluation method, acceptable by the experts was looked for, which could improve the typical defects of the weight method.

A multicriteria group method – new in the practice of EU funds – supporting analysis, assessment and selection of the key projects has been proposed and implemented within the study. The method enables evaluation and ranking of projects on the basis of assessments made by a group of independent experts. The method includes full procedure of activities of the experts, starting from a formal definition of the multicriteria decision making problem, and leading to the final selection of the key projects. An implementation of the procedure is presented in the paper.

1. Procedure

In 2006, the Self-Government of the Mazovian Voivodship the competition for the key projects co-financed from the EU structural funds within the Regional Operational Program of the voivodship for 2007-2013. More than 150 projects applied for the competition. The list of the key projects had to be prepared together with the respective justification. The projects not qualified as the key projects could apply again in the standard competitions organized later.

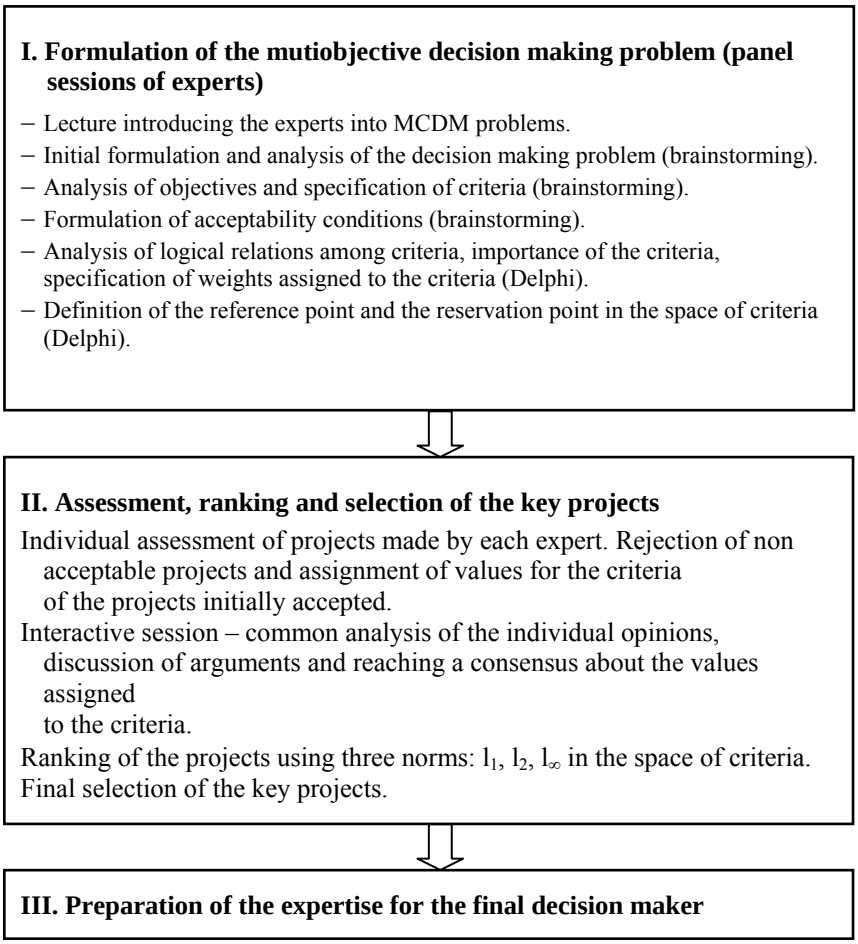

Figure 2. Scheme of the procedure

A procedure, schematically shown in Figure 2, has been proposed and approved. The figure presents activities performed by a group of experts, leading to the preparation of the list of the selected key projects. It consists of three main stages.

The first stage deals with formulation of the multicriteria decision making problem (MCDM). It started with a lecture introducing the experts to MCDM problems. The proper formulation of the problem requires the specification of the following key components (see [2]):

– Decision making unit. It is the decision maker and possibly a collection of men and machines acting as an information processor and generating the decision. In general, it can be the single or the group decision maker, system analysts, computing and graphical instruments.

– Set of objectives and their hierarchy. The objective defines the state of the system required by the decision maker.

– Set of criteria (attributes), relations objectives – criteria, the scales on which the criteria are measured. The values of the criteria measure the degrees of the attainment of the objectives.

– Decision situation that defines the problem structure and the decision environment of the decision problem. The description of a decision situation should include the specification of input information required and accessible, set of alternatives, constraints, decision variables, relations: decision variables – criteria, and finally the states of the decision environment.

– Decision rule. The rule includes processing of the input information, analysis, value judgment, decision generation and implementation.

These elements were considered and specified during the case study.

The following work of experts was organized in the form of a panel session with application of the brainstorming technique or the Delphi method, referred to in brackets. At the end of the first phase the experts were asked to define the best and the worst key projects in their opinion. These projects, considered as points in the space of criteria, refer, respectively, to the reference and the reservation point concepts in multicriteria analysis.

The second phase deals with the assessment method based on the cardinal approach to multicriteria group decision making. It includes individual assessments of projects made by the experts, joint analysis of the individual opinions to reach a consensus, ranking and final selection of the projects. The ranking is based on the distance of a given project measured to the reference point in the multicriteria space. Different norms are used to measure the distance. A special session was organized to make the final selection of the key projects.

The third phase refers to formal preparation of the expertise including the above-mentioned list of the recommended key projects, and the description of the implemented method and argumentation.

2. Multiobjective decision problem

2.1. Decision making unit and specification of objectives

The decision unit was the Board of the Self-Government of the Mazovian Voivodship, responsible for the final decision. The decision was prepared by the Department of Strategy and Regional Development of the Board and by the Mazovian Bureau for Regional Development.

The meaning of the "key projects" had to be specified first as the basis for the formulation of objectives. The working team has been organized; it consisted of experts from the Department of the Strategy and Regional Development of the Government, experts from the Mazovian Bureau for Regional Planning in Warsaw and an adviser responsible for group multicriteria decision support. Working sessions have been organized in which the brainstorming technique was used ([6]; [22]). The technique enables free and unlimited presentation of proposals but with strictly defined rules of analysis and evaluation of the proposals.

The team of experts decided that as the key projects such projects should be selected which substantially realize the directions of the activities specified in the development strategy of the province, taking into account: the directions of the spatial management defined in the spatial plan of the province, the competitiveness of the province in the international and the national contexts, the effects of synergy with other socio-economic spheres, and innovativeness. The acceptability conditions have been specified. The projects that do not effect structural, socio-economic and spatial changes in the region, or belong to other operational programs or have local character or do not fulfill the objectives of the Regional Operational Program for 2007-2013, should be rejected.

2.2. Input information, documents

The main objectives of the cohesion policy, taking into account the socio--economic conditions in Poland, are included in the document entitled "National Strategic Reference Framework for 2007-2013". The document, elaborated according to the EU directives, defines support directions for funding available

from the EU budget in the forthcoming seven years within the European Regional Development Fund and the Cohesion Fund. It is a reference instrument for the development of operational programs. According to the document, the regional development programs have been elaborated, negotiated and adopted by the EU Commission. In the voivodships other documents are also prepared, such as development strategies, spatial management plans and others.

The team analyzed the respective documents and decided that the assessment of projects should be made according to the objectives and the directions of activities given in the Development Strategy of the Mazovia Province till 2020, according to the objectives and priorities of the Regional Operational Program of the voivodship for 2007-2013, and to the specifications given in the Plan of Spatial Management of the Mazovia Province. The documents as well as the application questionnaires formed the information base for the project assessment.

2.3. Features of the decision problem

It has been found that the set of the objectives, which should be taken into account, is really complex. The Development Strategy of the Province till 2020 presents a hierarchical system including an overall objective, strategic and indirect objectives, and directions of activities. The Regional Operational Program (ROP) for 2007-2013 includes also a hierarchical set of objectives, priorities and directions of activities. The criteria respective to the objectives have qualitative character. The projects submitted within the different priorities are hardly comparable.

It has been found that the information included in the existing questionnaires is very limited. These questionnaires were elaborated earlier.

The decision had to be prepared in a very short time. The entire process, including preparation of the method, organization of the interactive sessions, assessment of all the projects, derivation of the ranking and the final list of the key projects had to be conducted in 10 days. The team had no earlier experience in such work.

3. Specification of criteria, reference and reservation projects

The experts have been informed how they should understand the meaning of objectives and criteria. The objective defines the required state of the system that the DM would like to achieve. The criteria specified for an objective measure (on a numerical scale) the degree to which the objective is achieved.

The criteria should fulfill the following requirements ([8]). The values of the criteria should define the achievement level of the respective objective in a unique and sufficient way. Each criterion should be comprehensive and measurable. A set of criteria should be:

- complete, i.e. all pertinent aspects of the decision problem are represented by the criteria,
- operational, i.e. it can be utilized in a meaningful manner in the ensuing analysis,
- decomposable, i.e. simplification of the evaluation process is possible by breaking up the decision process into stages,
- not redundant, i.e. no aspect of the decision problem is accounted for (by criteria) more than once,
- minimal – there is no other complete set of criteria representing the same problem with a smaller number of elements.

An interactive multi-round session has been organized in which experts worked according to the "brainstorming" technique. Proposals of criteria were generated to cover all the objectives specified in the Development Strategy of the Province and in the Regional Operational Program. The requirements presented above have been checked as well as accessibility of information from the application questionnaires. Finally, after analysis and discussion of all the objectives and their hierarchy, the following set of criteria has been specified, and unanimously accepted by all the experts:

K1. The degree of realization of the activity directions specified in the development strategy and in the spatial plan of the voivodship.

K2. The influence of the project on the competitiveness of the voivodship in the national and international context.

K3. Effects of synergy with other socio-economic spheres.

K4. Innovativeness of the project.

In the case of a large number of objectives specified in the above documents, the criteria have to be defined in an aggregated way. The experts have agreed on a method of checking the application sheets to evaluate the criteria of the projects assessed in the similar way.

Next, the experts were asked to define, according to their preferences, the best possible "key project", treated later as the reference project and the worst one, treated as the reservation project. They had also to analyze the logical relations of the criteria, to set the weights assigned to the criteria and to set the interval scales. The modified version of the Delphi method has been applied. The original Delphi method has been elaborated in the Rand Corporation, see

Linston, Turoof [16]. In the version implemented, the work of the group of experts was organized in the form of multi-round interactive sessions. In the consecutive rounds the experts' proposals were presented together with the respective argumentation. The proposals were jointly analyzed and discussed, especially in the case of divergent evaluations. On this basis, each expert could correct his opinion in the next round taking into account the arguments of other experts.

The weights assigned to the criteria have been fixed as follows: K1: 50%, K2: 20%, K3: 20%, K4: 10%.

The experts have defined the properties characterizing the best possible, in their opinion, key project. They specified when each criterion could be reached at the maximal level. The hypothetical project having all criteria at the maximum possible level was assumed as the reference project. The experts specified also the case when the particular criteria could be at the possible minimum level. This case refers to the hypothetical reservation project.

4. Project evaluation and ranking

An original method, which extends the cardinal approach described by Hwang, Yoon [6], has been proposed to the experts. In comparison with the classical approach, the concept of the reference point was used in place of the ideal point, several ways of measuring the distance to the reference point were applied and the Delphi method was used to find a consensus in the case of divergent opinions of experts. The reference point approach has been proposed and developed in the case of multicriteria analysis ([27], [28], [20], [21]). The reference point and the reference set concepts are developed by Konarzewska-Gubała ([9], [10]) in the case of multicriteria group decision support. It is also used in the methods supporting multicriteria cooperative decisions ([11], [12], [13]).

The method proposed enables the group, multicriteria judgment of projects in the case of qualitative criteria. The interval scales are used. Experts evaluate projects by assigning values for criteria using the scales. The experts' evaluations are discussed, corrected and set with use of the Delphi method. Each project is represented by a point in the space of criteria K1–K4. The ranking of projects is based on the distance to the reference point. Different ways of measuring the distance, compared also to the classical weight method have been proposed to the experts.

4.1. Idea of the evaluation method

We assume that the experts have equal power and their evaluations have equal importance. Each expert evaluates each criterion for a given project by proposing a value from a given scale interval. Values given by the experts are normalized. Let n be the number of experts, m – the number of evaluated projects, p – the number of criteria. The following steps are performed.

Step 1

Each expert k assigns a value a^k_{ij} to the project i for the criterion j. The normalized individual values are calculated:

$$d_{ij}^k = a_{ij}^k / \sqrt{\sum_{i=1}^{m} (a_{ij}^k)^2} \text{ , where } k=1..n,\ i=1,..,m,\ j=1,..,p.$$

The values are aggregated in the matrix

$$C = [c_{ij}] = \sum_{k=1}^{n} d_{ij}^k / n \ .$$

A vector of weights is given: $W=\{w_1,..,w_p\}$, such that $\sum_{j=1,...,p} w_j = 1$.

The collective values are derived in the matrix

$$F=[f_{ij}]=[c_{ij}w_j],\ i=1,..,m,\ j=1,..,p.$$

Step 2

The reference project defined by the experts in Section 3 is considered as the reference point in the space of criteria:

$$A^* = \{f^*_1,..f^*_p\},$$

and the reservation project, as the point:

$$A^- = \{f^-_1,..f^-_p\}.$$

Step 3

The importance ("value") of each project is derived on the basis of the distance between this project and the reference one. The distance can be measured in different ways. Three measures have been proposed to the experts and then considered by them.

The distance measured according to the norm l_1:

$$s_{i1} = \sum_{j=1}^{p} | f^*_j - f_{ij} | \text{ , where } i= 1,...m, \qquad (1)$$

– according to the Euclidean norm l_2:

$$s_{i2} = \sqrt{\sum_{j=1}^{p} (f_{ij} - f^*_j)^2}\ , \tag{2}$$

– according to the Chebyshev norm l_∞:

$$s_{i\infty} = max\ (|f^*_1 - f_{i1}|,...,|f^*_p - f_{ip}|). \tag{3}$$

Step 4

The distance of a project i to the reference one is normalized to the 10-points scale.

$$Gi = 10 \times (1 - si/s), \quad 0 \le Gi \le 10,\ i = 1,..m, \tag{4}$$

where s is the distance of the point A^- (reservation) to the reference point A^*. A greater value of Gi means that the project i is better. The project equivalent to the reference one gets 10 points, while to the reservation one - 0 points. It can be shown that in the case considered, the evaluation of projects with use of the the norm l_1 coincides with the evaluation obtained by the classical methods of weights.

4.2. Implementation

The above general idea of the method has been presented to and discussed with the experts. In the proposal, the values a_{ij}^k can be assigned by each expert in his own individual, arbitrarily assumed interval scale for each criterion. The normalized values d_{ij}^k are used in further steps of the procedure. The normalization can be done after all projects have been evaluated by a given expert. This means that the evaluations of the same project given by the different experts can not be compared before. The experts asked for the possibility to compare their evaluations at the earlier stages of the procedure and they all agreed to use the same scale. They decided to use the scale of 10 points for each criterion, assuming 10 points for any criterion on the reference project level and 0 points to for any criterion on the reservation level. The first criterion was divided into two subcriteria: K1a – the degree of realization of the activity directions defined in the development strategy of the province (assessed on the scale of 0-7 points), and K1b – the degree of realization of the directions of the spatial management defined in the spatial plan of the province (0-3 points). The experts decided that these sub-criteria are additive.

Initially, the experts evaluated several projects. The different rankings of the projects according to the norms (1), (2), (3) and according to the classical weights method were derived and presented to the experts. Figs 3, 4, and 5

illustrate the methods of ranking. The set of projects is shown in each figure as a set of points in the space of two weighted criteria. The reference and the reservation points are shown. The continuous lines represent sets of projects being at the same distance to the reference point, i.e. being in the same position in the ranking.

The classical method of weights is shown in Figure 3. Selection of the key projects means that a border line of distance to the reference point has to be assumed. The projects below the line are rejected. Our real problem is considered in a four dimensional space. The border is defined in this case by a hyperplane. The weight method is very popular and often applied in practice due to its simplicity and practicality. The question arises: Does it really reflect the preferences of experts? Let us look at the project with a low value of the criterion k_2 and a very high value of the other criterion (the project in question is indicated in Figure 3). This project would be higher in the ranking than projects with balanced values of all criteria. Is this really correct according to the intuition of the experts? The weight method is justified if the criteria are additive. In general, the description of the experts' preferences may be nonlinear. The rankings derived with use of the norms l_2 and $l\infty$ serve as examples of such nonlinear descriptions of the preferences. Of course, it is also possible to use other nonlinear descriptions.

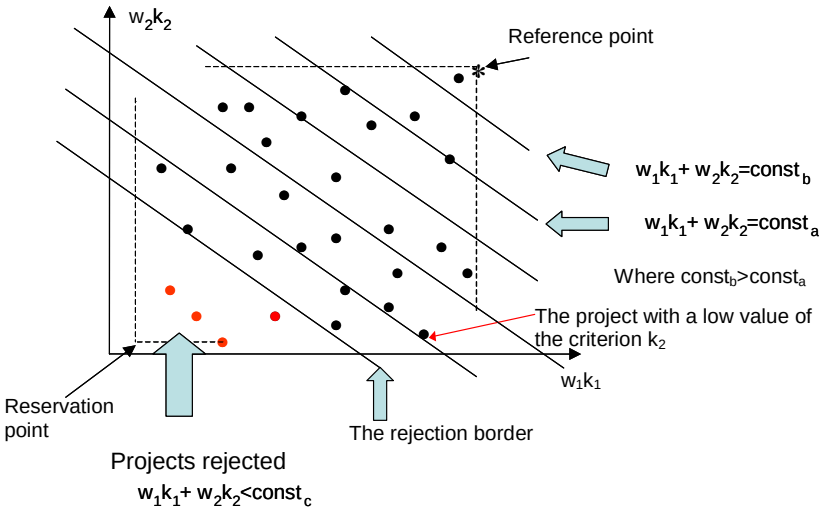

Figure 3. The evaluation and ranking of projects according to the classical weight method

The experts decided that the key projects should be selected using the Euclidean norm. The rankings defined with use of the norm $l\infty$ and by the weight method were derived for the sake of comparison.

In practice, in typical implementations, each project is assessed by five-seven or a larger number of experts. Once the values are given by the experts, the extreme values are rejected and the mean value is derived as the joint one. In the case study considered, the time for the entire procedure was very limited. All the projects had to be analyzed and evaluated in a few days. The team of experts consisted of seven specialists. In the solution applied, each project was analyzed and assessed independently by the experts from the Department for the Strategy and Regional Development of the Self-Government and from the Bureau for the Regional Planning of the Mazovian Voivodship. The experts checked whether a given project satisfied acceptability conditions mentioned in Section 2.1, and if so, made the assessment according to the assumed set of criteria. The assessments were treated as introductory. A special interactive session was organized after the individual assessments had been made. In the session, the projects and the introductory opinions were analyzed again by all the experts,

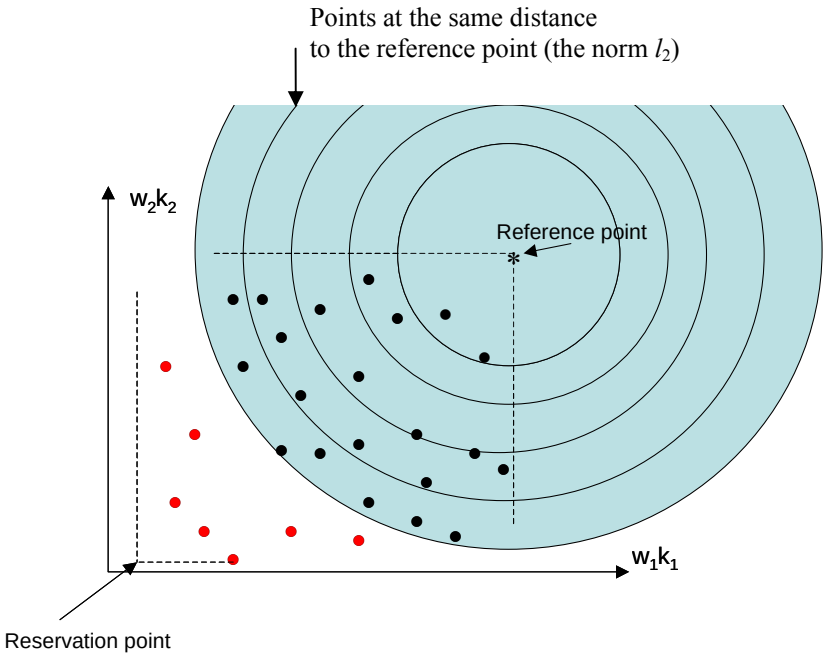

Figure 4. The evaluation and ranking of projects according to the distance to the reference point (the distance measured by the Euclidean norm l_2)

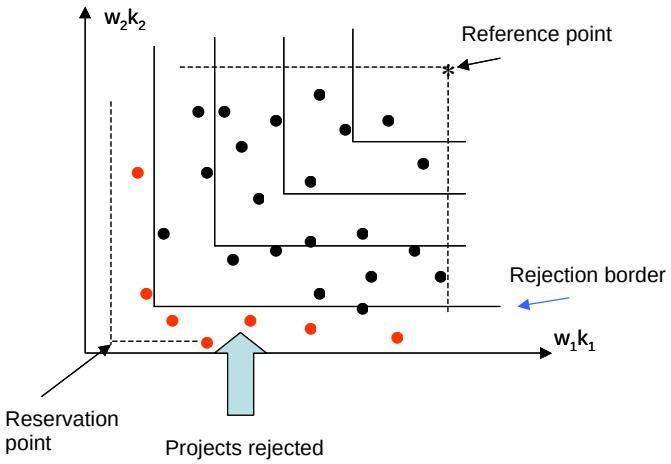

Figure 5. The evaluation and ranking of projects according to the distance to the reference point (the distance measured by the norm $l\infty$)

especially in the case of divergent introductory opinions. The opinions could be corrected after the discussion and the negotiation of arguments according to the Delphi method. The experts were supported during the session by a computer-based system.

The system takes as inputs the experts' opinions. On this basis it produces evaluations of projects, derives the distance of each project to the reference point according to the Euclidean norm, and also according to the l_1 and $l\infty$ norms. It generates the respective ranking lists. The system works interactively. Experts can correct their opinions on-line, obtain corrected results, analyze project evaluations and observe changes in the ranking lists.

The entire evaluation process was carried on under the confidentiality conditions required by the Ministry of Regional Development supervising the competition. The application sheets are confidential and could be analyzed by experts on premises only. Detailed information about individual evaluations, discussions, and preliminary scores is also confidential. The experts accepted the procedure proposed and performed their work without difficulties. From the operational point of view, the individual assessments were made in the same way as in the traditional method. Only aggregated scores and analyzed variants

of the ranking list were derived not by hand, but by the computer-based system. Only in the case of 10% of the projects, the individual opinions differed significantly. In this case, the experts had to present their argumentations during the final session and to discuss their opinions to reach a consensus. In all the cases, they reached a consensus. A special discussion was needed to decide where to make the rejection border in the ranking list of all the projects. The projects with scores near the border discussed were additionally analyzed, so that the final decision was justified, and accepted unanimously.

The resulting list of the key projects established and approved by the team of experts, and the ranking list of all the projects have been presented and recommended to the Board of the Self-Government of the Mazovian Voivodship. On the basis of the list and the opinions of the experts, the indicative investment plan has been elaborated and accepted by the Board of the Self-Government of Mazovia. The list of the key projects is presented on the website of the Self-Government.

Conclusions

A specially prepared group multicriteria method, original in the practice of EU funds allocation, has been applied to make the ranking and selection of the key projects. The ideas of different approaches have been used including the brainstorming techniques, the Delphi method and the extended cardinal approach to the group multicriteria decision making. To make the ranking, the positions of the projects in the multidimensional space of criteria are analyzed. On the basis of the experts' opinions the distance of each project to the reference key project is derived. The projects closest to the reference one are selected as the key projects. It has been found that the experts, when comparing several different measures of distance, have not selected the classical weight method but the nonlinear measure based on the Euclidean norm.

The weight method, frequently used, is justified under the assumption that all criteria are additive in the preference relation. In general, the assumption can be not fulfilled, but in practical implementations, it is frequently even not checked.

In this case study, the experts could make a choice. They did not approve the weight method, but selected and approved a non-linear description of their preferences according to the Euclidean norm for measuring the distance of each project to the reference „key" project.

The method has been elaborated and implemented by the commission from the Mazovian Bureau for Regional Planning in Warsaw [14]. The final list of the selected key projects was the basis for the indicative investment plan elaborated and accepted by the Board of the Self-Government of the Mazovia Voivodship.

In future work applications of the bipolar reference system ideas proposed by Konarzewska-Gubała [9] and developed by Trzaskalik [26] and of the interactive approach to ordinal regression multiple criteria ranking using a set of additive value functions [5] are planned.

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