SYSTEMS RESEARCH INSTITUTE
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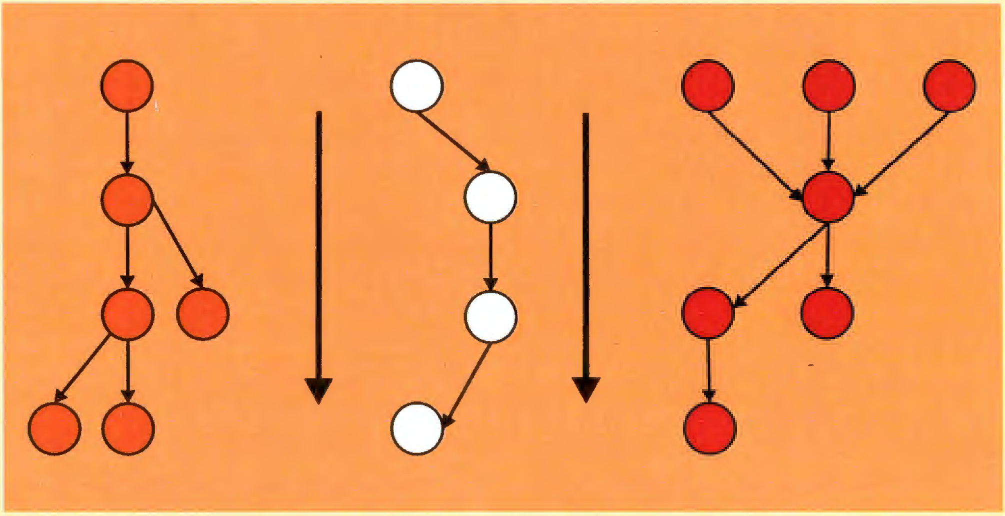
MULTICRITERIA ORDERING AND RANKING:
PARTIAL ORDERS, AMBIGUITIES AND APPLIED ISSUES



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This book is the outcome of the international workshop held in Warsaw in October 2008 within the premises of the Systems Research Institute. All papers were refereed and underwent appropriate modification in order to appear in the volume. The views contained in the papers are, however, not necessarily those officially held by the respective institutions involved, especially the Systems Research Institute of the Polish Academy of Sciences.

ISBN 83-894-7521-9
EAN 9788389475213

Technical editing and typesetting:
Jan W.Owsiński, Anna Gostyńska, Aneta M.Pielak

Pragmatic Issues in Business and Administration

Ranking and Ordering: Some Practical Issues with a Bearing on Methodological and Technical Requirements

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The paper presents a couple of examples of situations, in which ranking and ordering of objects in presence of multiple criteria should be performed, with a certain practical objective in mind. These situations are shortly characterized, along with the pragmatic requirements as to the methods and techniques used. Some conclusions are formulated, related mainly to the pragmatic aspect of the methods and techniques developed and applied, and they are actually applied.

Keywords: multicriteria ranking, multicriteria ordering, aggregation, weighting

1. Introduction

In this non-technical paper we shall concentrate on a couple of real-life examples where, at least according to certain principles, multicriteria ranking and ordering is in place. We shall, namely, look in a somewhat deeper detail into three domains: (1) organization and running of tenders; (2) multi-attribute evaluation of project progress and achievements; and (3) ranking of administrative units in terms of development levels with the view on effectiveness of use of definite funds. While commenting on these three we shall also allude to some similar cases, as the need and opportunity arises.

[1] This research has been partly supported in the framework of the 6 FP European Project 44495 - FARO EU, and partly within the Polish project ANAGMIS: contract with the Ministry of Science and Higher Education No 9008/H03/2006/31, project N11400/31/1404.

The primary goal of the paper is to turn attention to the relatively simple, but often disregarded, problems, that arise in the circumstances like those here considered. These problems may indeed be of purely technical nature, but often shall have a decisive bearing on the ultimate outcome of a procedure, and not necessarily in a wanted direction, at that. In view of the diversity of concrete situations, no general remedies are proposed, except for few remarks, but, instead, it is suggested that adequate care is taken of all these problems, if troubles are to be avoided. The way to deal with them, whenever they cannot be resolved a priori through application of certain – preferably simple and intuitive – technical approaches is to carry out a true-to-life simulation of the potential course of the procedure, with representation of various types of feasible behaviour.

In the paper we shall use the following notation: objects evaluated are numbered with index i, $i \in I = \{1,\ldots,n\}$, while variables, or criteria, or attributes, with index k, $k \in K = \{1,\ldots,m\}$. In case of necessity we shall refer to different sets or subsets of the two, using the same general notation, (I and K) with appropriate subscripts or superscripts. We shall assume that each object i is characterized by the m values of variables, and thus can be represented as a vector $x_i = [x_{i1},\ldots,x_{ik},\ldots x_{im}]$, x_{ik} being the value of variable k for object i. Note that we do not assume anything about the nature of x_{ik}, which may be any real numbers, intervals, fuzzy numbers, etc., provided we are capable of "properly" processing them further on.

2. Tenders

2.1. The framework

We do not mean here, of course, the tenders, which are simple auctions or bidding situations. Rather, we address tenders, which often occur in public domain, where not just price is the criterion used, but also other criteria are explicitly, and formally, accounted for, associated mostly with product or service quality, reliability of the provider, etc.

In such tenders usually not just the one, winning, option is selected, but the entire ranking of options is determined, which is important in view of the open procedure, in which offering bodies often try to inspect the correctness of the entire process, and also because within a definite deadline after the evaluation of options the winning party (like any other party) can still withdraw from the tender, and so the need arises of having the "subsequent winners", if the rules so stipulate.

Here, of course, i's correspond to options or offering bodies, and k to criteria used.

Let us start with the explanation why "automatic" procedures are not used in such tenders. In fact, since price, which is most often the leading criterion, is measurable, and one could think of similar measures for other criteria, provided their values can be ordered (by, e.g., assigning ranks to the materials, from which a given product shall be made, or to the references, provided by the offering bodies). First, though, it is obvious that in a general case such a procedure is not feasible (there would be no unanimous agreement as to the ordering of qualitative feature "values", or we fall into infinite regression trap), and, second, even if (real or discrete) values of a criterion variable are provided, the nature of the respective evaluation space (e.g. strong nonlinearity) may bring about additional issues, leading, again, to problems mentioned above. Thus, for instance, human experts shall know better whether a given value is "normal" or "strange" or "exorbitant". That is why we assume the procedure is realized with human experts providing their evaluations in the form of values of x_{ikv}, where $v \in \{1, \ldots, u\} = V$ are the indices of experts, taking part in the procedure.

The basic assumptions behind this kind of procedure are related also to the magnitude of the problem, it is namely assumed that n, m and u are rather small, to make the procedure effectively manageable. Typical, illustrative numbers would be n=15, m=4, u=6. Even for such a small example we deal altogether with 15x4x6=360 values x_{ikv}, which means that appropriate organizational measures, even if very simple, must be undertaken.

The two fundamental paths, taken in practical cases, from x_{ikv} to the final ordering of options, are as follows:

$$x_{ikv} \rightarrow [a] \rightarrow x_{ik} \rightarrow [b] \rightarrow c_i \rightarrow o_i \qquad (1)$$

$$x_{ikv} \rightarrow [b'] \rightarrow x_{iv} \rightarrow [a'] \rightarrow c_i \rightarrow o_i \qquad (2)$$

where [a], [a'] and [b], [b'] are pairs of analogous, though not necessarily identical, aggregation operations, c_i are the final aggregate evaluations of the options, and o_i are the associated ranks of these options.

The crucial issue behind the procedure, that of limited or nonexistent commensurability of various criteria, is dealt with in the framework of (1) or (2) (or [a], [b]) through two kinds of assumptions:

I. The relative importance of the evaluations provided by particular experts. It is usually assumed, for various reasons, that all experts are equal in these terms. In some cases the tipping voice is given the chairperson, so as to avoid a hypothetical stalemate, although this is not in general at all necessary. Thus, [a] takes on the simplest form of:

[a]: $x_{ik} = (\Sigma_v x_{ikv})/u.$ (3)

II. The relative importance of the criteria, expressed, as a rule, through the pre-defined weights of these criteria, w_k, with the usual constraint of $\Sigma_k w_k = 1$ (or 100%). Definition of the weights usually constitutes one of the preparatory steps to the tender. Once the weights established, we have:

[b]: $c_i = \Sigma_k w_k x_{ik}.$ (4)

We have thus provided a description of a very common situation, a framework, within which tender-related decisions are made. We shall now proceed to an example, serving as illustration for the main problems arising in realization of this simple procedure.

2.2. An example

Before presenting the example to consider in more detail, we shall only deal away with the often forwarded proposal of "voting" by distributing a definite total number of score points per expert, i.e.

$\Sigma_i x_{ikv} = X^*$ for all k and v. (5)

This is a convenient technique in that the grand total of points is kept constant, as can be easily checked with (3) and (4) above. Yet, it has two important disadvantages: first, it requires from experts strict calculation of the scores in order to keep (5) satisfied; second – in order to keep the technique simple, we would like to have X^* relatively small, e.g., =10, and to allow the experts to assign only integer values of scores; this, however, sets prohibitive constraints on the possible scoring (strictly monotonic scoring of more than five options is no longer feasible: 0+1+2+3+4=10); for higher X^* (e.g. =100) the negative impact from the first reservation becomes even bigger, and the benefit of simplicity is lost.

Thus, let us consider an example of a table of stylized evaluations for the case when n=5, m=4, and u=6. Assume, quite reasonably, that all criteria are ordered in the same manner (the higher the better) and that the experts are asked to assign integer values from the interval between 0 (lowest-potentially worst) and 9 (highest-potentially best) as x_{ikv}. It should be emphasized that this table illustrates real-life behaviour, only somewhat stylised.

	k=1						*k*=2						*k*=3						*k*=4					
v	*1*	*2*	*3*	*4*	*5*	*6*	*1*	*2*	*3*	*4*	*5*	*6*	*1*	*2*	*3*	*4*	*5*	*6*	*1*	*2*	*3*	*4*	*5*	*6*
i																								
1	9	9	5	9	8	9	3	4	1	3	2	2	9	9	8	9	6	9	9	8	6	8	9	6
2	3	8	3	1	5	7	3	3	1	3	1	2	9	9	8	9	6	8	8	8	8	8	8	6
3	2	7	2	1	4	4	3	3	1	3	1	2	9	9	8	9	6	8	8	8	9	6	8	6
4	1	6	1	1	2	2	3	3	1	3	1	2	9	9	8	9	6	8	7	8	4	5	7	6
5	0	5	0	0	2	0	4	5	1	6	3	4	9	9	8	9	6	8	8	8	9	6	9	6

A Reader is invited to check the numbers in the matrix, just to see the essential phenomena. We shall, though, start with an explanation concerning criterion variables:

k=1: price, anyway taken with the highest weight of $w_1 = 0.5$; the (unit) prices are well defined real numbers with no additional aspects;

k=2: additional offer (additional services, like transport, archiving, etc.); these are declarations of what the offering body can do in addition to the main product / service in question;

k=3: formal declaration of liability in case of default, of quality guarantee etc.; usually a formal statement of flat payment or sum due, or other legal or financial warranty;

k=4: product (service) quality assessment, based on the exemplary items presented.

We shall now comment on and analyse the quotations shown for individual criterion variables separately.

k=1:

i	*v=1*	*2*	*3*	*4*	*5*	*6*
1	9	9	5	9	8	9
2	3	8	3	1	5	7
3	2	7	2	1	4	4
4	1	6	1	1	2	2
5	0	5	0	0	2	0

One might be surprised by the differences in expert quotations for such a simple exercise. Yet, this is what happens actually: experts' perceptions of the "quality" of prices against the market, as they see it, and against the given object of tender, may be completely different. The rationales for such different perceptions might be (and actually are) as follows:

- $v = 1$: the fact that someone quoted the lowest price is the most important; the differences among the other ones are of much lesser importance;

- $v = 2$: the scores should correspond strictly to the order of prices quoted, without any distinction with respect to the differences between prices, starting with the highest score;

- $v = 3$: as above, ending with the lowest score;

- $v = 4$: as for $v=1$, but with a sharper distinction between the best price and the rest;

- $v = 5$: the scores should correspond to the relative levels of prices (or other criteria) quoted;

- $v = 6$: as above, but with a different perception of the significance of prices offered.

Thus, we can see two main sources of differences in quotations, shaping the results in an important manner: (1) the differences in the very *principles* of scoring (mainly with respect to the differences of ranks); and (2) the attribution of score values in the framework of particular principles – the difference of *perception*.

As we stick to the overruling principle of *simplicity* (experts are following very simple and clear rule of "voting", like the one exemplified in (5)), we are not allowed to enforce more elaborate and stringent principles of scoring. In fact, let us note, in the example quoted, none of the experts was "unfair", nor even went to the extremes of what was feasible, namely scoring equally two options differing as to the variable value ("actually, I do not see [much of a] difference between the two").

Thus, we face the Scylla and Charybdis of impossibility of (fully) automating the procedure in view of a bulk of *tacit knowledge* that can hardly be easily accommodated in such automated systems (should we create an *expert system* for each case of tender in question?) and the unexpected effects of employing (quite rightly!) experts, having differing perceptions of the case at hand.

In case of clear domination the situation like the one above is not harmful, but it is definitely not for coping with clear domination that we should be prepared.

$k = 2$

i	*v=1*	*2*	*3*	*4*	*5*	*6*
1	3	4	1	3	2	2
2	3	3	1	3	1	2
3	3	3	1	3	1	2
4	3	3	1	3	1	2
5	4	5	1	6	3	4

Most of the tender participants offered just "transport of goods to customers", but for an additional payment. Offer no.1 suggested that such transport, to a certain degree, might not be charged. Only offer no.5 included use of the own website of the company to promote the product provided.

In this case behaviour of experts does not give rise to any doubts. Yet, we are already confronted with break of domination. In addition, the issue of "proportionality" or "linearity", which arose even in case of k=1, that seemed so straightforward, gets seriously compounded when the basis of scoring gets "qualitative".

We shall omit here the scores for k=3 (satisfaction of formal warranty requirements), since almost all experts considered these requirements be satisfied (equally) by all the tender participants. The sole exception is constituted by the expert no. v=6, who evidently "liked" the warranty provided with the offer i=1 more than the other ones.

$k = 4$

i	*v=1*	*2*	*3*	*4*	*5*	*6*
1	9	8	6	8	9	6
2	8	8	8	8	8	6
3	8	8	9	6	8	6
4	7	8	4	5	7	6
5	8	8	9	6	9	6

As we get into increasingly "qualitative" variables, this one is explicitly about "quality". And, of course, the scores are quite diversified. To illustrate this, table below shows the ranks of offers according to the scores above:

i	*v=1*	*2*	*3*	*4*	*5*	*6*	*Σ*
1	1	1	3	1	1	1	8
2	2	1	2	1	2	1	9
3	2	1	1	2	2	1	9
4	3	1	4	3	3	1	12
5	2	1	1	2	1	1	8

Definitely, offer i=4 is the worst with this respect, but the other ones seem to be hardly discernible.

Intuition prompts us to indicate offer i=1 as the "winner", despite the (single) case of the variable that breaks the domination of the offer.

Now, according to the procedure of [a][b], i.e. (3),(4), we obtain the results as shown in the table that follows:

i	*k = 1*	*2*	*3*	*4*	*Σ*
1	8.17	2.50	8.33	7.67	26.67
2	4.50	2.17	8.17	7.67	22.51
3	3.33	2.17	8.17	7.50	21.17
4	2.17	2.17	8.17	6.17	18.68
5	1.17	3.83	8.17	7.67	20.84

Although observations that can be made on the basis of this example are largely trivial, they may nevertheless be of importance for the practical organization of the procedure. In order not to prolong this section, we shall summarise these observations, together with conclusions, in a separate point.

2.3. Some observations and conclusions

i. In case of multicriteria tenders, with criteria of diverse nature, and variously quantifiable, including, potentially, nominal variables, it is necessary to employ a committee of experts, who assess the options through a definite procedure.

ii. The above is also true for the ("fully") quantifiable variables, given the possibly (essentially) nonlinear character of the mapping from the space of variable values to the potential assessments and the degree of reliability of these values, especially in conjunction with values of other variables-criteria (e.g. on variable $k1$ the more the better, but beyond some value, if variable $k2$ takes low values, the quotation becomes doubtful).

iii. The tacit knowledge, alluded to above, can to a large extent be turned into the content of an expert system, but it is inconceivable that an expert system be built – or even modified – for each tender case (also because many factors involved and their properties change over time and from tender to tender even within one well-defined class).

iv. The procedure of "voting" or "scoring" by experts must be kept very simple, like the classical one here exemplified, for reasons of clarity and transparency, and interpretation (possibility of facile discussion).

v. Such a simple procedure, even if reasonable, does not safeguard against "strange" behaviour of experts and therefore also against "strange" results (e.g. in the example considered, quite "well-behaved", after all, a default of the winning offer would leave as the best the option $i=1$, which, compared formally to $i=5$ does not dominate at all).

vi. Some of the problems may be avoided if the scoring stage is preceded by a discussion, during which some of the voting rules, exceeding the formal procedure, are established (e.g. the level of prices considered "unreasonable" on both ends, the ways of dealing with qualitative aspects, etc.).

vii. Valuable additional information would therefore be constituted by the domination structure, such as, in particular, provided by the Hasse diagrams. Of special importance would be indication of the (weakly) dominated options, so as to eliminate them from further considerations, if possible – already at the initial stage of the procedure (before the proper scoring stage), under the assumption that no "reversals" are feasible.

We can hardly avoid and safeguard against refined cheating, but we can make it more difficult and more obvious, and help to overcome the consequences of (honest) differences in perceptions, both as to the evaluation and the way of evaluating.

3. Assessment of achievement degree of comprehensive projects

3.1. The outline of situation

It has become not only popular, but also necessary, especially in view of use of the outside funding (including the support from the EU funds), to develop the schemes allowing for evaluation of the degree of progress and achievement of objectives for a broad class of projects. This applies, in a particular manner, to projects, carried out by the local and self-governmental administration, oriented at development and re-development of definite areas, social infrastructure, as well as general infrastructure. We mean here, first of all, the projects, whose goals are multiple, and often hard to quantify, but even in the case of "simple" technical infrastructure projects (e.g. road construction) similar procedures are used.

A typical project from the class here considered would consist in sanitation of a small portion of a city, composed of a couple of street segments, buildings and infrastructure, with the general aim of protecting the area from falling into marginalization. This would consist in repair and modernization of buildings, repair of the street and sidewalk surfaces, modernization of street lighting, provision of the adequate quality dwelling and service space, etc.

It is frequent that in a bigger city, or region, several such projects, differing, of course, significantly as to their subject matter content, are simultaneously realized. For each of them the problem arises of adequate tracking and evaluating the degree of achievement.

There are two features, which make design, development and use of such constructs a difficult issue. First is the *multiplicity and complex structure of the goals and objectives of the projects*. We deal, in a way in the same time, with quite specific and concrete yardsticks like the length of road surface built (compared to the envisaged total length) or the percentage of households served by the sewage system under modernization (against the total envisaged) or the number of persons having gone through training courses, and the very general, qualitative, and hard-to-assess goals, like increase of attractiveness of the area, or the feeling of safety, or the human capital improvement.

It is often so that these goals and objectives are grouped into two or three "layers" in a quasi-formal manner, primarily on the basis of their (material) concreteness and possibility of measurement. Thus, we often deal with the so-called "*products*", for which definite and strict plans can be set, and the degree of achievement easily measured (what has been done? and: how this compares to the plan set?). The criteria "above" the "products" can either also be measurable, at least to some extent (e.g. percentage of trainees having found jobs during six months after the completion of training against a certain background data), or hardly so (like those mentioned before). On this basis we shall refer to these, "higher level", criteria as "*effects*" (when they are quite directly related to "products", and can be somehow measured), and, yet higher, "*objectives*", being the ultimate goals of the respective projects (e.g. improvement of livelihood).

It can be seen how difficult it is to structure the criteria so as to obtain a coherent system, allowing for a synthetic and comprehensive appraisal of the progress and achievements. Thus, in particular, in reality, the level of "objectives" is rarely addressed during project execution. An analysis is done prior to the project execution and then, sometimes, as post-hoc appraisal, after a period of time.

Thus, we deal with three subsets of criteria, *KP*, *KE* and *KO*, of, respectively, products, effects and objectives. For any practical purpose it can be assumed that they are mutually disjoint. The distinction between *KP* and *KE* is not only made on the basis of the "level of generality", but, to a large extent, due to the specific dependence of items in *KE* on those in *KP* (e.g. a criterion from *KE* can be properly assessed only after some criterion from *KP* has attained a definite degree of progress). Hopefully, the same can be said of relation between *KO* and *KE*.

On the top of this, even if we consider the projects from a definite class within a given region or agglomeration, they differ significantly as to the applicability of individual criteria. An assessment system, developed for a broad range of projects, shall always have a lot of non-applicable items, the sets of such items differing from project to project.

Note, at the end of this consideration, that we do not address here at all the fundamental question of correspondence of the criteria from the sets *KP*, *KE* and *KO*, in the sense of a "model", i.e. interrelations among the variables forming individual criteria. We assume, for the sake of simplicity, that the entire system of criteria has sense.

Yet, there is also another problem that has to be dealt with effectively, compounding the difficulties, namely that in the majority of cases there might be *significant divergences in the realization of projects from the planned goals and thresholds*. This must not necessarily lead to non-achievement of the ultimate objectives, or to a different degree of achievement of individual objectives than envisaged, which would be still generally satisfactory. The assessment system has to accommodate the possibility of such variations.

Finally, let us emphasize again that this sort of problems (tracking of projects already underway) is characterized by a relatively low (or unknown, but in each case not too high) n, and a high m, reaching in some instances several hundred, split into mp, me and mo, corresponding to KP, KE and KO.

Yet, an akin situation, though of different substantial meaning, and, indeed, proportions, arises when we deal with a priori project assessment for purposes of granting assistance funds to projects. We can then have n in the range of thousands, m being much lower than envisaged here, and the evaluations done by different experts (in view of the scale of n). The evaluation extends, though, only to a definite subset of criteria, and the uncertainty has a completely different nature than in the case considered: no changes in realization actually occur. This sort of setting is addressed by Kruś (2008a,b), with a constructive and pragmatic approach, aimed at obtaining aggregate ordering of multiple projects evaluated by several experts on several criteria of diverse significance and level.

3.2. What is that we need?

In many instances it is simply necessary to develop computer-based monitoring and assessment systems that should help in the management of individual projects and their comprehensive up-to-date assessment. Given the above, such systems ought to secure, first, the adequate documentation of the state of things (incoming reports have to be accounted for and signalled, in a possibly simple manner, e.g. as attachments, indexed for each of the envisaged entries[2]). Then, they ought to be organized as simple fill-in forms, with an explicit possibility, later on, to manage the entries ("valid", "no longer valid", "change of parameter" – meaning, for instance, the total to be achieved, or the price or cost coefficient), with appropriate tracking of the changes introduced. Some of the required features are summarized in the table below.

Thus, overall, we need simple and effective fill-the-form applications, with facility of editing in a variety of meanings (items, names, assignments, scales, scores, ...), the latter not so easy if simplicity is to be maintained. These

[2] The entries, which are supposed (or formally required) to be based on reporting documents, will have to be appropriately flagged in the "type-in" system.

functionalities reduce, in fact, to editing of the sets *KP*, *KE* and *KO* and to establishing the weights in aggregation, if allowed for.

Level of consideration	**Examples of category**	**Number of**	**Functionality required**
Products	- length of pavement border built (in metres) - number of households with sewage system installed - number of trainees - % share of area covered with monitoring	Several dozen or several hundred	Quick establishment, review, change, scaling, scoring and commenting; assignment to effects / objectives
Effects	- % share of street length with improved sidewalks - % share of trainees having got a job within 6 months - increase, in %, of the number of trespassers identified in a day	At most several dozen	Facility of structuring; scoring and change, with changes documented; possibility of visualizing scoring
Objectives	- improvement of aesthetic aspect of the area - increase of the (relative) estate price - decrease of unemployment rate among the young - decrease of crime rate	A couple (most preferably 2-5), if not just one	Facility of structuring, scoring and change; possibility of visualizing scoring and achievement degrees

The place for more refined techniques resides in two aspects: (1) assessment of relative achievement over time; (2) assessment of achievement with respect to various effects / objectives, which, provided they can at all be anyhow compared, could lead to a comprehensive and integrated evaluation.

4. Evaluation of development levels and dynamics

4.1. The setting

There are policies, which are being applied to relatively large (at least a couple of dozens) sets of supposedly similar entities, with the aim of attaining better (higher) values of certain indicators, usually multiple. Under definite conditions, usually of commercial character ("resource-wise efficiency"), techniques like Data

Envelopement Analysis (DEA) can be used for this purpose. Yet, for reasons of both immanent differentiation of the entities, to which policies are applied (while, still, the policies have to be the same, at least in principle, for all of them), and the necessity of accounting for quite diverse characteristics of the entities ("input" and "output" type, "resource" and "effect", etc.), it is necessary to allow for the more explicit treatment of the various aspects, and for the possibility of an insight into the interrelations among them.

The primary object of the considerations, contained here, is the set of territorial units, composing a country, in this case – Polish municipalities (roughly 2,500 in total) and Polish counties (roughly 350 in total). The diversity of these units can be well illustrated by the data below (Owsiński, 2008a,b):

	Area in km²	*Population*	*Own revenues of communal budgets, in PLN (Polish zlotys)*	*Revenues from personal income tax, in PLN*
Minima	3.32	1 321	520 400	99 000
Maxima	634.80	1 692 854	4 855 300 000	2 086 895 000
Ratio of max to min	Min x **200**	Min x **1 000**	Min x **10 000**	Min x **20 000**

Given this range of diversity, and this yet in various dimensions, no wonder special approaches are necessary, coupled with effective tools for managing them, at least at the level of data analysis and gaining insight into the structure of the population considered. Ranking and ordering of the members of these populations is here in place inasmuch as definite means are being distributed in accordance with certain principles, usually being functions of (variables determining) ranks in respective orderings.

4.2. Some approaches available and the needs arising

To deal with the problem, especially from the viewpoint of equilibrated ("sustainable") development of the territorial units, an approach was developed within the ANAGMIS project by Gadomski (2008). This approach is based on a novel, non-classical utility function. It is very effective in measuring "development utility" with indication of the degree of disequilibrium (unsustainable development), but our primary concern here is with explicit treatment of the multidimensional and multicriteria nature of the evaluation space and the population of units evaluated.

Similarly, the interactive approaches, like the one illustrated in Chmielewski et al. (2008), or more complex systems, aiming, though, also at more intricate problems, like presented by Becker (2008), or the pragmatic approach of Kruś (2008a,b), do not tackle explicitly the issue that we are mainly after, that is – the structure implied by the space of criteria used on the one hand and the actual distribution of the objects evaluated in this space.

It is possible to use the simple techniques for identification of the breakeven weight values like in Owsiński and Więcław (2007) (where this is done for pairs and triples of variables, and high numbers of objects), i.e. the weight distributions, at which orders are changed (reversed). A similar problem is in a way considered in the context of the Hasse diagram related techniques, in connection with the concept of linear extensions, see numerous papers in this volume. The question we put forward here, though, is not a simple outgrowth of the existing linear extension related techniques, since it presupposes explicit optimization (minimum number of explicit weights, minimum weight measure, etc.). A development of such techniques is very welcome, indeed, but is still a question of the future, in view of:

- necessity of accounting for a high number of objects,
- need for relatively simple and intuitively traceable results (if not the procedure), and
- possibility of intervening in case a choice is offered (objective function in optimisation, selection among equivalent solutions, etc.).

This, indeed, is one of the open perspectives for future work.

5. Some conclusions

There are quite pragmatic issues, related to ranking and ordering, which arise in various applied domains, and these call for developments in the existing techniques, such developments ranging from theoretical constructs and properties (existence, optimality) through methods and their justification, down to techniques and (interactive and simple to manipulate) software products.

This, therefore, quite optimistically, leaves quite a broad field ahead for the research and development work in the field.

References

Becker J. (2008) Architektura informatycznego systemu generowania wielokryterialnych rozwiązań decyzyjnych: koncepcja budowy modelu WPL oparta na niestandardowych zadaniach decyzyjnych (Architecture of a computer-based system for generating multicriteria decision solutions: the concept of development of the WPL model based on non-standard decision problems; in Polish). In: J.W. Owsiński, Z. Nahorski and T. Szapiro, Eds., *Badania operacyjne i systemowe: decyzje, gospodarka, kapitał ludzki i jakość. Badania Systemowe*, **64**, Instytut Badań Systemowych PAN, Warszawa, 103-112.

Chmielewski M., Kaliszewski I., Sobczak E. (2008) Wielokryterialne szeregowanie gmin z wykorzystaniem systemu SWPD (Multicriteria ordering of municipalities using the SWPD system; in Polish). In: J.W. Owsiński, Z. Nahorski and T. Szapiro, Eds., *Badania operacyjne i systemowe: decyzje, gospodarka, kapitał ludzki i jakość. Badania Systemowe*, **64**, Instytut Badań Systemowych PAN, Warszawa, 81-90.

Gadomski J. (2008) Ocena rozwoju jednostek samorządu terytorialnego. Uwagi metodyczne (Evaluation of development of the territorial self-government units. Methodological observations; in Polish). In: O. Hryniewicz, A. Straszak, J. Studziński, eds., *Badania operacyjne i systemowe: środowisko naturalne, przestrzeń, optymalizacja. Badania Systemowe*, **63**. Instytut Badań Systemowych PAN, Warszawa, 197-210.

Kruś L. (2008a) Wielokryterialna ocena i wybór projektów kluczowych aplikujących o środki UE (Multicriteria evaluation and choice of key projects applying for EU funds; in Polish). In: J.W. Owsiński, Z. Nahorski and T. Szapiro, Eds., *Badania operacyjne i systemowe: decyzje, gospodarka, kapitał ludzki i jakość. Badania Systemowe*, **64**, Instytut Badań Systemowych PAN, Warszawa, 91-102.

Kruś L. (2008b) Some experiences with a group multicriteria method for project evaluation. In this volume.

Owsiński J.W. and Więcław A. (2007) Finding the Odd-Man-Out in Development Scoring and Classifications. In: O. Hryniewicz, J. Studziński, A. Szediw, eds., *Environmental Informatics and Systems Research*. Vol. 2: Workshop and application papers. Shaker Verlag, Aachen, 195-199.

Owsiński J.W. (2008a) On measurement of sustainability and life quality in Polish municipalities. In: O. Hryniewicz, A. Straszak, J. Studziński, eds., *Badania operacyjne i systemowe: środowisko naturalne, przestrzeń, optymalizacja.*

Badania Systemowe, **63**. Instytut Badań Systemowych PAN, Warszawa, 185-195.

Owsiński J.W. (2008b) How can we read out life quality assessments from the official socio-economic data on Polish municipalities? In: W.Ostasiewicz, ed., *Quality of Life Improvement Through Social Cohesion. Proc. of the 4th International Conference*. Wrocław University of Economics, Department of Statistics, 140-155.

This book is a collection of papers, prepared in connection with the 8th International Workshop on partial orders, their theoretical and applied developments, which took place in Warsaw, at the Systems Research Institute, in October 2008. The papers deal with software developments (PYHASSE and other existing software), theoretical problems of ranking and ordering under various assumed analytic and decision-making-oriented conditions, as well as experimental studies and down-to-earth pragmatic questions.

ISBN 83-894-7521-9
EAN 9788389475213