DECISION MAKING AS A RESEARCH BRANCH: METHODOLOGICAL PROBLEMS

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PRACTICAL NEEDS IN DECISION METHODS

Anyone encountering problems of complex decision making in a new situation where no established rules may be used can conceive the complexity of such problems. Complex, unique [15] decisions have to be made both in human business activities and personal life. In particular, all problems of a strategic character can be referred to them. A human being making a decision on resource allocation, appointment to a position, etc., usually takes account of a host of various and nonformalizable factors, opinions of other people, his own knowledge and experience, etc. It is clear that a successful solution of a problem (recognized successful by the majority of people concerned and/or allowing us to obtain sound objective results) depends primarily on the skill of the decision maker to take his cue in a complex situation, the ability to identify essential and sacrifice minor things, to anticipate the future course of events. As is known, the human qualities of a manager to a considerable extent determine his ability to find a correct decision. Far more complex are the group decision problems. The latter are defined in the course of discussions, when new information emerges and trade-offs are made on the basis of mutual concessions and struggle of influences. All this allows us to comprehend why many decision makers question the significance of any analysis for complex decision making.

Why then is there a need in any methods for decision alternative analysis? Why is the personality of a talented manager insufficient for a successful solution of all problems?

There are, in our opinion, three major groups of reasons determining the utility of decision methods.

1. *Systematization of the Decision Making Process resulting in a Larger Volume of Information Available for the Decision Maker*

The analysis of complex decision alternatives requires additional information and the assistance of experts. The application of decision methods makes it possible to systematize the process: to prompt the manager to look for people representing different points of view on the considered issue; to define the relevant information; to develop procedures of its elicitation and representation, etc.

2. *Extension of the Actual Decision Maker Capabilities to Perceive Complex Multifactor Information*

An experienced manager usually knows what he wants and pursues a definite policy in the problem of choice. This policy is generally formulated through the search for information and by discussion of hypotheses on the possible implications of some or other decisions. In problems of unique decisions, however, this policy represents a trade-off between problem complexity and decision maker capabilities. The latter are limited and the major constraints are set not so much by the individual abilities of the decision maker as by the general characteristics of the human information processing system. Thus, the limited volume of short-term memory makes man resort to different ways of data classification [9, 13] and employ different heuristics [1, 29]. An experienced decision maker knows the key factors to be considered in the course of decision making, but employs them inconsistently, by simplified rules. The plasticity of man, his ability to adapt information to his capacities, do him an ill turn in this case: "compression" of information leads to errors in estimates. In the simplest case, the human being just neglects part of the criteria [29]. Utilizing more complex and seemingly fully justified methods — disregard of small differences in estimates by one and the same criterion — human beings fall into a "trap of inconsistency" (see A. Tversky [29]).

A reasonable application of decision methods allows us to expose the essence of choice to the decision maker, to consciously develop trade-offs and more consistently pursue a certain policy.

3. *Enlistment of Consultant Services for Solving the Problems of Choice*

Numerous day-to-day responsibilities often divert a manager from problems of strategic choice. Meanwhile, they belong to the range of tasks not to be delegated. The decision methods generally "come" to a decision maker together with a decision consultant. In fact, the consultant extends the decision maker's capacities in elicitation of information, formulation and realization of a certain policy.

These groups of reasons justify, from the practical point of view, the existence of the problem of decision methods development as an independent branch of research. They do not characterize the current potential of decision methods but rather indicate the problems demanding solution.

DECISION MAKING AS AN INDEPENDENT RESEARCH BRANCH

There are indications that a new branch of research, referred to as "decision making", has been established by the present time. There are numerous publications, special journals, books, bibliographies with a large number of entries devoted to this topic. Most often decision making is interpreted as a nonrecurring process of human choice of an alternative characterized by estimates of multiple criteria. Along with the aforementioned problem presentation, consideration is given (less often, though) to others: a choice made by a group of people (group decisions), a choice under risk, uncertainty, recurring choice, etc. What then is the difference between decision problems and those of operations research? First of all, lack of an explicit and objective structure of the problem under study.

Most characteristic of decision making as an independent branch of research is a problem where the structure is a subjective perception by a human being, or a group of people, of interrelationships between system parameters. What is more, the very composition of considered parameters sometimes depends on perception, on the "world outlook". In the course of decision alternative evaluation these parameters act as criteria. Thus, the decision maker plays the central part which sharply distinguishes the given range of problems from those of operations research.

Most often, the "decision making" branch is concerned with the so-called ill-structured or nonstructured problems [32]. Of course, problems with an objectively assigned structure (under multiple criteria) are sometimes considered within the framework of decision making [17]. These problems, however, are on the boundary with well-structured operations research problems [18].

From the same point of view, decision making is close to systems analysis in the sense that J. Schlesinger has successfully expressed as follows: "If systems analysis is adapted so that it is recognized as dealing with issues wherein the clash between multiple and incommensurable goals must be settled by judgment" [31]. Of course this perception is far from that of A. Quade [25], characteristic of the first applications of systems analysis to military-engineering systems. The Schlesinger definition quite adequately describes the current practical activities in the field of systems analysis. The review of relevant papers reveals two basic components of systems analysis [15]:

1. A series of logical steps of problem study (identify goals and resources, identify decision alternatives, evaluate the alternatives, compare them).
2. Methods of alternative assessment on the basis of subjective judgement.

The second component is close to what is most often understood as decision making. The development of alternative comparison techniques is the major line of research in decision making. At the same time systems analysis, as is known, is designed for the solution of ill-structured problems, while decision making, as a branch of research, is oriented both at ill-structured and nonstructured problems lacking quantitative variables. Thus, recent years have witnessed publications on the application of decision methods for analysis of problems of job choice, family planning [10], i.e. for typical nonstructured problems.

It is also necessary to distinguish between the branch of research known as "artificial intelligence" [4] and decision making. The artificial intelligence studies are most often concerned with stimulating procedures of problem solution by people. As for the decision making studies, they are mostly concerned with assisting decision makers, with building subjective models reflecting the problem perception by the decision maker (or a group of decision makers). The models are generally prescriptive, i.e. they prescribe a choice rule rather than describe the procedures of human choice.

The problems presently referred to decision making have the following distinguishing characteristics:

1. A complete or partial lack of an objective model of the considered problem (ill-structured and nonstructured problems).
2. A subjective nature of decision alternative evaluation rules.
3. Consideration of numerous criteria in the course of alternative evaluation.
4. Orientation at prescriptive models providing decision makers with a rule of choice.

It would be wrong to say that these peculiarities are characteristic of the majority of papers concerned with decision making. The actual state-of-the-art in this field presents a complex picture. Most often, researchers fall into three groups differing in lines of activities: (1) psychologists, engaged in the study and description of real decision making procedures; (2) mathematicians, dealing with axiomatic representation and study of choice models; (3) specialists on normative models, prescribing to people the rules of rational choice. At present, these groups of researchers are completely isolated, though there are appeals for joining efforts and infrequent "intrusions upon foreign areas" (see overview of literature on: behavioral aspects of decision making [33]; mathematical aspects [39]; normative methods [16, 17]).

SEARCH FOR DECISION METHOD VALIDATION

If some area of research could be singled out by characteristic features and by the number of researchers labelling their products in similar terms, and if the utility of the area could be justified from a practical point of view, then a question arises concerning the scientific basis of the area and the evaluation criteria for the obtained results.

In our opinion, the basic outcome of research in this field is normative (prescriptive) decision techniques. It is these methods that justify the independent existence of the area. Should they disappear, the research area will break into one of particular branches of psychology and a particular branch *of* applied mathematics.

What is then the scientific validation of choice of some or other normative method? What is the basis allowing to determine that one method is superior to the other?

At present, there are two distinct lines in validating decision methods. One of them is associated with utility theory [24]. The problem of alternative evaluation, within the framework of this line, is reduced to a problem of axiomatic validation and construction of utility function. Each set of axioms is associated with a certain type of utility function. The problem comes to testing, on the basis of decision maker's information, the validity of some or other axioms. The ideology *of* this approach is very well represented by a book of H. Raiffa and R. Keeney [11].

Quite different validation is required for the approach connected with the application of a group of direct methods (methods where the form of dependence of the resulting alternative utility on its multicriteria estimates is assigned in advance).

Validation is carried out by choosing one of the "principles" *of* reconciliation of individual criteria estimates (principle of uniformity, just concession, etc.) [3]. The choice of principle is done by a decision maker on the basis of "common sense".

In the majority of normative decision methods the choice of the method is validated by its conformity to some or other characteristics of real problems, conveniencies to the decision maker, etc. Therefore, some proponents of axiomatic approach call them heuristic, thus contrasting all other techniques to axiomatic ones as the only "scientifically-based".

In fact, from the formal point of view the validation of axiomatic methods seems perfect. But for all this, however, they have been criticized in recent years. In his witty review of Raiffa and Keeny's book P. Rivett, a prominent British expert in operations research, notes [26] that axiomatic methods do not suit the solution of real problems and are not used in practice. Many *of* the critics point out that these methods treat the decision maker as a faultless and omnipotent utility gauge [38]. The real human limits in information processing escape the notice of axiomatic method developers, though in recent years there have been numerous demonstrations of the limits [29, 35]. We should add the following to the above considerations.

As far as impossibility of a full test of axioms is concerned, axiomatic and heuristic methods do not differ very much in practice. In fact, all suggested methods of axiom tests are heuristic procedures, as validated as heuristic techniques *per se.* What is more, heuristic methods of compensation, incommensurability threshold, man-machine procedures [17], much more suit the specific features of a host of practical problems.

The thing is, from a pragmatic point of view, it is not at all necessary to build a utility function in many situations. Thus, for example, given a small number of alternatives and a large number of criteria, the pairwise alternative comparison by additive difference techniques [34] or by the ELECTRA method [28]) generally produces a required result. At the same time, the utility function construction, with axiomatic methods, requires many hours of the decision maker's co-operation and unwonted and complex questions to him.

In one of Keeney's exercises [12], it took eight hours of joint work with a decision maker to build a utility function, though it was necessary to compare a mere six alternatives.

Therefore, many experts do not consider axiomatic validation of the utility function a satisfactory tool for normative decision method.

Unfortunately, the choice of the "reconciliation principle" in direct methods is as inadequate. This choice must be made by the decision maker, though it is rather difficult from an informational point of view. E. S. Ventsel was right to observe that reduction of an alternative comparison problem to a choice of principles means "arbitrariness carried from one level to the other" [37]. The point is that while choosing a "principle", man must somehow analyse its implications, i.e. acceptability of the alternatives chosen for it. This, however, is equivalent to a direct evaluation of multivariate alternatives. It is well known that problems of multivariate alternative comparison and evaluation are very difficult for the decision maker; he solves them with considerable errors [29, 23]. The choice of the evaluation "principle" is far more complex than a direct choice of multivariate alternative.

ASSESSMENT OF DECISION METHOD CORRECTNESS

It can be easily seen that the critique of the well-known ways of normative decision method validation is based on incorrectness of the ways of information elicitation from people. Subject to critique both the methods are associated with mathematical (axiomatic) validation and the methods employing "common sense" or "conveniency for the decision maker" for validation. Judging from the critique, an impression is made that mathematical strictness is not an adequate validation of method correctness. An appeal to common sense is especially dangerous in cases where the possibilities of information elicitation from human beings have been studied insufficiently and forms and methods of information elicitation have not been defined. The results of the latest studies [35] give "common sense" a surprise. The critique of the well-known method validation once again emphasizes the fact that the most urgent problem in designing decision methods is the problem of information elicitation from people. Hence, the method validation should probably be looked for in psychology rather than mathematics.

We believe that quite a different validation of decision method correctness is possible. Behind each normative decision technique there is some or other information elicited from decision makers and experts (e.g. "assign criteria weights", "compare differences in estimates of two alternatives by two criteria", "find an indifference point for two lotteries", etc.). It is necessary to answer the question as to what extent the actual human capabilities in information processing correspond to the requirements of a decision method. Should we be in a position to say that the method requirements correspond to the possibilities of eliciting reliable information from people, then the method can be considered correct. Otherwise, it is not.

The suggested validation of method correctness requires an answer to the question as to how and by what criteria the human capabilities in information processing should be assessed?

Some interesting results were obtained in the last five to seven years, demonstrating what a human being cannot do in decision problems. Thus, A. Tversky, D. Kahneman and a number of other researchers demonstrated that people make extremely unreliable estimates of subjective event probabilities [35, 7]. It was repeatedly proved that people make systematic errors in identifying preferences in lotteries [5] and make errors in assigning criteria weights [33]. Recent studies [29] have confirmed the results of previous studies [23] which showed that comparison of objects with multi-criteria estimates is too difficult for a human being. Generalization of the results obtained is to be found in overviews [1, 15, 33]. Note that only those results are meant that have been repeatedly confirmed in psychological experiments, in contrast to intuitive arguments as to "What information is easy for a decision maker?"

What criteria were used in psychological research for evaluating human actions in information processing?

First of all, we should note the experiments in which the correct answers of an objective nature were known in advance [30]. Comparison of human performance results with the known correct answers is a good criterion. Unfortunately, such comparisons are not always possible: far from all decision problems have correct answers known in advance.

The second widespread criterion is consistency, stability in expressing preferences (e.g. identical estimates for the same objects at the second exposure).

Finally, transitivity is a rather common criterion. Very often experiments are designed so that people feature intransitivity when faced with too complex problems.

We have suggested [15, 22] a fourth criterion — complexity of decision rule (as applied to multicriteria problems). The point is that for a host of problems the application of the first criterion is not possible, while the second and third ones can be met only with a rather primitive policy when nearly all criteria are transferred into constraints. At the same time, an experienced decision maker yearns for the most effective use of all criteria essential for him. It is probably just to this that in their experiments D. Russo and A. Tversky had preliminarily selected the subjects employing all criteria in decision making (i.e. combinations of estimates by multiple criteria). In expressing a complex policy through the use of combinations of multiple criteria estimates, the limited capabilities of human beings manifest themselves in the form of discrepancies and inconsistencies in estimates.

Thus, three criteria *of* decision maker capability evaluation can be used for decision problems with multiple criteria: consistency, transitivity and availability of complex strategies.

What is known thus far about the reliable (according to the listed criteria) elicitation methods of decision maker preferences?

It is well known that in a case where a problem can be solved through the use of one of the usual decision maker's heuristics (three of the most common heuristics are discussed in [29]), then the decision *is* quite reliable.

It is known that given a certain number of scale estimate criteria, human beings can directly classify multivariate alternatives [19]. A hypothesis on the limits of capabilities was tested in [20].

It is known also that man can be taught to better evaluate subjective event probabilities. As is known, the application of several different heuristics substantially reduces the number of errors made in the comparison of multi-criteria objects [29]. It is known also that utilization of verbal definitions of criteria scale estimates [15] allows us to more reliably elicit decision maker preferences. In particular, one may obtain a consistent and complex policy by means of pairwise comparison of utility decrease along the two criteria scales, while the other criteria estimates are either better or worse [21]. We do not claim the completeness of the information, though it reveals that there are reliable methods for eliciting information required for the design of normative decision methods.

COMPARISON OF THE CORRECTNESS OF TWO METHODS

Let us consider two well-known man-machine decision procedures — the Dyer-Gioffrion method [8] and the constraints method [2] — from the point of view of information required for a decision maker when employing the method.

Both methods are designed for a class of problems where there is an objective model of the considered problem, but the quality of decision is evaluated by several criteria. The procedures of the best decision choice by the given method are a cyclic process of interaction between man and computer. A cycle consists of a phase of analysis and man-made intermediate decision, and an optimization phase exercised by the computer. Different man-machine methods vary in information required at the phases of analysis and intermediate decision making.

According to the Dyer-Gioffrion method, a decision maker has to determine, in any point of criteria space, the multidimensional gradient (direction of utility function growth). A decision maker performs it as follows. He chooses one of the criteria as a reference one and determines the increment of any other criterion value that makes up for the assigned variation of the reference criterion value. Following the choice of direction, the decision maker considers the points along the direction and selects the best one (corresponding to the maximum utility).

As for the STEM method (constraints method), at each stage the decision maker identifies a criterion featuring the worst value at a given iteration. The decision maker determines a constraint on the value by the given criterion ("not worse than").

The requirements set by the Dyer-Gioffrion method to a decision maker are too complex for him. It was noted [27] that when facing small increments of objective functions, a decision maker often erroneously determines the gradient of utility function. As complicated for the decision maker is the search for an extremum along the direction in multidimensional space, as this is equivalent to comparison of alternatives with multiple criteria estimates. Since the Dyer-Geoffrion method requires such information from a decision maker that cannot be considered reliable, it cannot be treated as correct.

The constraints method requires quite customary operations to be performed by the decision maker — successive transfer of criteria to constraints by assigning satisfactory values. It was demonstrated [6, 36] that this behavior is characteristic of people, it is associated with the search for "satisfactory" (according to Simon) decisions. Of course, inadequate consideration is given to criteria interrelationships that can result in an increased number of cycles. But from the point of view of information required from a decision maker, the constraints method can be treated as correct and scientifically-based.

ON THE DESIGN OF CORRECT DECISION METHODS

The design of a new normative decision method is based on the following initial data:

1. The availability or lack of an objective model.

2. The number of criteria, nature of criterion estimate scales (discrete, continuous), number of estimates on scales (given discrete scales).
3. The number of alternatives, possibility of obtaining information about each alternative by all criteria prior to decision rule formulation; chance of new alternative emergence in the course of decision making.
4. The nature of alternative estimates (objective, expert judgement); possibility of obtaining information from unbiased experts; number of potential experts; nature of required estimates (relating to the present, forecasting).
5. The type of required decision (single out one alternative, a group of alternatives, order alternatives, etc.); lead time between elicitation of information about the alternatives and presentation of decision.
6. The time that a decision maker can spare for the problem; availability of several decision makers with differing policies, stability of decision maker preferences.

Some part of the aforementioned factors can be considered in the design of the method application procedure, others in the development of the method proper. The key stage in the development of a decision method is the validation of form and type of information elicited from decision makers and experts. The validation can be carried out as follows.
A hypothesis is formulated on the possibilities of eliciting a certain kind of information from a decision maker and experts, sufficient for passing over to a required decision. Of course, in case the hypothesis had been tested earlier and found plausible, it can be just used without any testing. Otherwise, special simulation experiments are needed to check it. A scenario of a decision making model situation is developed quite familiar to a potential group of subjects. A group of subjects comprising 6-15 people is selected (this number *is* quite usual for psychometric research in the field of decision making). Some of the subjects contribute to the development of a list of criteria and estimate scale. Then, a psychometric experiment is staged in the course of which subjects evaluate alternatives. The experimenter tries to put the subjects in the decision maker's position and increase their motivation in the search for an evaluation strategy. The experiment procedure is built so that the subject answers could be checked for consistency (a part of alternatives is repeated) and transitivity (through transitive closures of alternative sets). Each subject is given estimates of answers by two criteria: consistency and transitivity. Besides, the subject answers allow us to identify their evaluation strategies. First a question *is* to be answered whether people employ simplified strategies, as is often the case, in problems complex for subjects. Naturally, the perception of criteria and estimates is quite specific with each subject. However, while preparing an experiment the researcher tries to choose criteria and estimates to arouse a desire with at least part of the subjects to employ a rather complex strategy, making use of different combinations of criteria estimates. Should the experiment reveal that all subjects (or the ones with a small number of errors) used simple criteria truncation strategies, then one of the following conclusions is made: (1) the evaluation problem is complex for the subjects; (2) the simulation experiment is a failure and more complex decision situations and other criteria are required. In case the simulation experiment provides quite positive results (a group of subjects assigns estimates in a clearly nonrandom manner, the majority of subjects have a small number of errors, there are complex strategies), then the results of the hypothesis test can be considered successful and the given method of preference elicitation can be applied to real problems, when working with decision makers. Should the hypothesis test fail, the given type of questions is undesirable for the work with decision makers, i.e. it is highly probable that the questions can be too complex.
Of course, in real decision problems the decision maker's motivation is higher and perception of the strategy is better than with many of the subjects in a simulated situation.
The positive results of the hypothesis test in simulation experiments can, however, be viewed as an indispensable condition for application of certain procedures of decision maker preference elicitation. Without preliminary verification it would be unreasonable to employ the procedures in practice. Positive verification results provide a certain guarantee for the work with an unknown decision maker. Without the guarantees, there is a danger of too complex questions being put to a decision maker who, when answering them, makes a lot of mistakes and employs simplified strategies.
The positive results of the hypothesis test do not cancel the necessity of decision maker preference verification (for consistency and transitivity) when employing the given type of questions.
To exemplify, there are VYBOR (Choice) [15, 19] and ZAPROS (Inquiry) [15, 21] methods developed and validated in this way.
We should note that as the number of papers on elicitation of reliable information from people increases, the problem of correct decision methods development gets considerably simplified.
There are obvious historical links between decision making and operations research as well as continuity of numerous ideas. What is more, some decision making problems constitute characteristic problems of operations research with multiple criteria [17, 14]. The basic criteria of scientific character and validity of results in operations research are identical to those in natural sciences: mathematical strictness, recurrence of results under similar initial conditions, objective models.
The subjective nature of the model in typical decision problems changes the result evaluation criteria. The emphasis is placed on the correctness of method of information elicitation from the participants of decision making process. The understanding of the specific nature of activities in this field is, in our opinion, one of the prerequisites for obtaining new and interesting results.

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