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IIASA Working Paper

WP-77-013

1977

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October 1977 WP-77-13

2361
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1. Two Types of Decision-Making

The important role of decisions in the whole process of management on all the levels is unquestionable now.

In practical work every manager in business deals with decisions devoted both to so-called "technico-economic" business and "management" decisions in the proper sense of the word where the latter reflects the essence of the management, its role in coordination and organization, the management itself (where the former are the decisions which deal with the object of management). The best sign of the management decision is the presence of the feature of coordinating the activity of people to achieve the goal (which, of course, does not mean that the managerial decisions deal only with "collective" decisions in the Luse-Raiffa meaning; a director's decision to promote someone is an individual management decision (see Chapters 13 and 14 in [1]).

The distinction between the former and the latter is not purely a linguistic one. Due to many reasons the main efforts were directed to the "optimal" techno-economic decisions; this can be represented in the well-known form:

$$\begin{cases} F\ (x) & \longrightarrow \quad \text{extr} \\ x \in X & . \end{cases}$$

But those well-structured problems mainly tackle technical problems, in which (a) the human and organizational factors play subordinate roles; (b) the statement of the problem is defined by the problem itself (criteria--for instance, minimum time, cost, etc.). In such a statement obviously the traditional stages of managerial decisions process (analysis of the present situation, the description of a set of alternatives, the statement of goals and criteria, the assessment of alternatives) are omitted. The main difference between the managerial and techno-economic decisions is not in fact that the latter can often be represented in a formal (equational) form (this advantage can easily be explained if one takes into consideration the fact that attention to the managerial decisions was drawn later than to the techno-economical ones. The main difference is that there is no real choice between the alternatives in techno-economic decisions: in those problems we have no choice, but search for a potentially existing decision (which is not the case with managerial decisions).

As a whole, techno-economic problems deal with the first five functions of a manager (according to Fayol): technical, financial, control and maintenance, but not with organizational functions. It is well-known that the techno-economic problems ("standard") constitute 75% of all decisions made by a manager which is why the skill to resolve these problems as well as possible, is a step forward, but it does not mean that we should deal only with them.

From some point of view pure managerial problems are much more interesting due to the fact that (i) in them the criteria and restrictions are not defined beforehand, that must be done in the process of decision making; (ii) it is very difficult to make them formalized; (iii) as a rule they have a lot of criteria; (iv) as a rule, "fuzziness" and bad defined terms are characteristic of them; and the most important (v) the decision must be made in an organization, from which the existence of different interests, different understanding and interpretation of measures, activities and goals, (which must be achieved in the result of decision making) follows.

Therefore we consider it necessary to study (a) the process of decision-making in real life organizations, (b) factors (human and organizational) which influence it, (c) collective and individual decisions in them, and (d) interpretation, communication and motivation in organizations. We should use methods of such sciences like psychology, sociology, social psychology to do so.

These problems became so urgent now, when we try (and which is more imporant, have) to use computers in man-machine systems for improvement of management. This cooperation becomes impossible if we do not know how man and man-made organizations make decisions (see [2]). This knowledge will help us to settle techno-economic problems too--the fact is that when we try to introduce into the statement of them such things like multi-criteria, dynamics, uncertainty, etc--we do it following the advice of existing methods, which are based only on mathematical conveniences, not on the essence of the tasks. (It is interesting to point out that the last 25% of "non standard" decisions determine the main variables, which influence considerably the life of an organization--goals, criteria, norms and moral standards in it, personnel policy, communication structure in it, etc.).

2. Continuous Decisions

There exists another very important distinction between the two kinds of problems. The management decision process consists of two parts: the search (formulation) for the decision and the work on its implementation (because the work on the implementation of techno-economic decisions is an organizational one). But both the decisions found in the scientific institute or made by the manager himself, when implemented, usually (someone thinking that always) have nothing in common with the proposed one: during the process of adjustment it may change greatly. We consider the underestimation of the implementation stage and the men and organizations which act on it, to be the main reason for this "gap" between made and implemented decisions.

To eliminate this gap we feel it necessary to consider the decision-making process as a continuous process of searching and implementation of the decision. This means that we should take into consideration the "internal parameters" of the organizations and managers, the collaboration and communication of men and organizations (which in practice sometimes may mean simply the participation of those who implement decision in the process of their elaboration). To some extent the existing methods of decision preparation (talks, meetings, collective and even open discussion on alternatives, preparation of drafts, visas, signatures, etc.) try (based on the experience of managers) to overcome the gap by means of the development of special procedures (strict control, personnel policy, good reports, explanation and agitation work, etc.)

To be able to consider a decision to be "continuous" in the process of its elaboration and implementation one should take into consideration not only the social-psychological parameters of the decision making organization, but also (a) goals, targets, resources, implementors, (b) time span, (c) existing rules, instructions, previous decisions on the subject, and (d) paramters of organizational structure and its cooperation with informal structure. (Really "continuous" decision should necessarily include in itself such things, for instance, like: which acts and instructions must be disabled and which ones must be prepared, etc.)

Continuous decision will facilitate tying decision and (a) goals, (b) resources, (c) personnel, (d) time-span, and (e) existing organizational structures.

Of course, we are far from the statement that the above mentioned features of continuous decisions are quite new ones (for example, the idea of participation was discussed in several places, see [2]). Our main intention is to point out that this intuitively and in practice obvious statement is considered to be an <u>art</u>, not an exact science. Nowadays to my mind, we considerably lack descriptive (not normative) <u>theory</u> of decision-making, which would be based on real life facts of behavior of organization and managers in the decision-making process.

3. Psychological Factors of Decision-Making

There is a number of parameters which could be included (or at least tested) into the decision making theory even now:

a) more realistic description of goal setting of men and organization (those which prevalent nowadays describe them like "seeker of maximum profit, utility, etc.--which in light of the presence of level-of-aspiration-achievement behavior lacks solid base);
b) more realistic testing of attitudes towards risk (in the theory of games and in statistical inferences man is considered to be an absolutely "rational being") even the simple usage of three types of risk aversion gave interesting results (see [3]);
c) logic of decision must be built which (unlike the works of Rescher or Wright) should take into account such facts like

intransitivity of preferences, incomplete order of alternatives, etc.;

d) time of perception and processing of information by collectives and men;

e) level of unity of groups or organization (presence of leader, kind of his authority, socioeconometric chart of the group, distribution of power between deviants and conformists, etc.);

f) emotions and affections, which now are considered to be a good assistance to a man in decision making under uncertainty (see [4]); and

g) principal inability for a man to imagine infinite (and even very large number) of alternatives at a time and "fuzzy" character of his thinking.

4. Model of Individual Decision-Making

Modeling life is a good and useful method of studying it, and therefore we will try to present here some models of man's behavior in decision-making situations which will explain at least some of the phonomena mentioned earlier.

Let us consider a set of "finite" lotteries M (in von Neuman-Morgenstern's sense [5]): ApB, such that: if A and B in M, then $ApB \in M$ also (where $0 \leq p \leq 1$ and ApB means lottery: to have A with a probability p or B with a probability 1-p). Let us assume:

A1. On M exists a linear, reflexive, transitive order $\gtrsim$.

A2. If $A > B$, then for all $0 \leq p \leq 1$, $A > ApB > b$.

A3. If $A > B > C$, then there exists p that $0 \leq p \leq 1$ and $B \sim ApC$.

A1-A3 were included, with a number of others, into a set of axioms in von Neuman-Morgenstern's work. They insured the existence of the utility function on M, because from them one could infer that in A3, p must be unique. But from A1-A3 we can not make this inference, that is there can exist a whole interval $P = [p_1, p_2]$ such that for any $p \in P$, $ApC \sim B$. This reflects the fact that any man cannot discriminate all the alternatives and/or numbers. This improvement makes impossible the inference of a "normal" utility function, but we succeeded in constructing a "fuzzy" utility function $U : M \to 6(E)$, where U now maps a set of alternatives not on the real numbers line E, but on the (constructively built) set of intervals E (see [6] for details). It is easy to notice that u(x) is really "fuzzy" in the Zadeth meaning.

From such a model we have some interesting conclusions. Let us introduce now the order on M in the following way:

B1. $A \succ^* B$ if, and only if, $A \succ B$ and $U(A) \cap U(B) = \emptyset$.

B2. $A \sim^* B$ if, and only if, $U(A) \cap U(B) \neq \emptyset$.

The newly constructed order $\succsim^*$, though symmetric and reflexive, is not transitive, which shows a possible way to explain why in real life, man often behaves "irrationally." In our previous paper, we showed the way to solve Allays paradox [7] using a fuzzy utility function.[1]

5. Model of Group Decision-Making

Another part of the future work might be the modeling of the decision-making process in organizations, which was described in a number of works, one of the most famous being Arrow's work on collective choice [8]. The main result of this was: decisions in organizations either depend on only one man ("dictatorship"], or independent ("imposed"). It seems to us that the reason for this disappointing results was that the basic assumptions about the human's and organization's behavior were too far from reality--they did not take into account the real mechanism of coordination of the interests in groups: role of leader, influence of the group on its members (which was discovered in Sherif's experiments [9] and confirmed in a series of other and different countries), etc.

The most primitive model of a leader's influence on the group decision-making might be stated as follows: let $P_i(x)$ be the probability that alternative x from M is the "best" for member i of the group. Let us describe two classical cases:

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[1] It is necessary to point out that in our opinion the main cause for the utility function being "fuzzy" is not the uncertainty of the information (because the target can, and must, be stated clearly) but is due to the existence of <u>many</u> different goals, which a manager or an organization pursues simultaneously.

(a) for some members i there exists a utility function for the preference $\succsim_i$ on M; then it is quite natural to assume, that $u_i(x) > u_i(y)$ if, and only if $p_i(x) > p_i(y)$;
(b) member i has a level of aspiration u_i^* (that means that for all $x_1, x_2 \in \{u/u(x) \geqslant u_i^*\} = A$, $x_1 \sim_i x_2$, and if $x_1 \in A$, $x_2 \notin A$, then $x_1 >_i x_2$). In this case $p_i(x)$ will be part linear one. (Of course usually we should not expect the occurence of both cases (a) and (b).

Then the process of decision-making will be described in two staged procedure: first step--every one has his own judgements, and compares them with the group's and with (particularly) the leader's preferences. The second step--adjustment of members' preferences ($p_i(x)$ to leaders: $p_i(x)$ becomes $p_i^*(x) = f(p.(x)_i\ p_{i_o}(x))$ where i_o is leader (it is worth trying $p_{i_o} \cdot p_i$ instead of f, or some other function).

6. Critique of Some Models of Decision-Making

Different models, describing human decision-making, were prepared by a lot of authors (see review in [1]). Their assumptions may be stated as follows:

a) decision-maker seeks optimum of utility index;
b) decision-maker is considered to be only one "being" (which means in case of organizations, that we omit or consider to be irrelevant such things as discrepancy of interests of different men, communicational problems, etc.); and
c) all the problems can be stated in "strict" terms (especially quantified).

Let us consider some of these models:

(1) A model describing a man who seeks "maximum expected utility" was proposed by J. Bermulli, which states that in the situation with uncertain outomes rational men must choose a strategy with the maximum expected utility of gain. Well-known Sanct-Peterbourgh Paradox was the first example, which showed that in real situation a man decides whether to take part in the game or not but the price of it is less than the expected utility. (Moreover, this price is chosen not in a pick-and-toss way, because the prices, defined by different people, turned out to be very close to each other.) That means, that there must exist other principles

describing man's behavior in decision-making processes. In a number of situations two strategies might have equal expected utilities, but one might be obviously better than the other (for example, the dispersion of one might be less). Therefore we should take into consideration not only the expected utility but, and this is much more important, we should firstly decide whether we can use statistical functions at all because we must know what kind of probability we consider--subjective or logical probabilities might turn out to be more adequate while decribing real behavior. The fact is that those problems which we described above as "managerial", occur very seldom (H. Simon calls them "unprogrammed") and therefore it is impossible to find any statistical functions (because a situation does not repeat itself).

Even the simple consideration of risk aversion violates the maximum expected utility principles. Let us assume a man estimates the outcome x of a game $u(x) = (x-4)^2$. Let us assume a game: $L = \begin{cases} \$+10 \text{ with probability } 0,5 \\ \$-2 \text{ with probability } 0,5 \end{cases}$

The expected gain from the participation is \$4 (= 10/2 - 2/2) which means that the utility of participation is zero: $u(4) = 0$. But the expected utility of gain is 36 $(= 0.5 \cdot (-2-4)^2 + 0,5 \cdot (10-4)^2)$ which means that a man will prefer to run a risk and take part in the game L sooner than receive a "sure" \$4.

Let us consider the application of the fuzzy utility function mentioned above to expected utility principle. Let $A_1 > A_2 > A_3$; from A1-A3 follows that there exists $R = [\underline{r} ; \bar{r}]$, such that for all $r \in R$, $A_2 \sim A_1 \; r \; A_3$ (win A_1 with probability r and A_3 with (1-r)). Natural generalization of Bermully's principle on a case of fuzzy measurements would have the following form:

$$(*) \quad \bar{u}\,(A_2) = \bar{r}\,\bar{u}\,(A_1) + (1-\bar{r})\,\bar{u}\,(A_3)$$
$$(**) \quad \underline{u}\,(A_2) = \underline{r}\,\underline{u}\,(A_1) + (1-\underline{r})\,\underline{u}\,(A_3)$$

where $u(A_i) = [\underline{u}(A_i);\ \bar{u}\ A_i)]$ - interval of real numbers line.

It is easy to show that if we already have $u(A_2)$ and $u(A_3)$ then to find $\underline{u}(A_1)$ and $\bar{u}(A_1)$ from (*) and (**) might have no sense. For example, it might turn out to be $\underline{u}(A_1) \quad \bar{u}(A_1)$, that is, alternative A_1 was maped by function u on null-set which is impossible. This means that in case of fuzzy measurements Bermulli's principle lacks proof.

(2) Another type of model is the usage of utility function, derived from preferences on set of alternatives M. If M is topoligical space, the follwing theorem is true:

Theorem (see [10]). If M connected and separable topological space with linear, transitive, antireflexive order $\succ$, then there exists a utility function "U" such that: $U(x) \succ U(y)$ if, and only if $x \succ y$. (Another kind of of theorem was proven by Debreu, Rader, etc.) But for vector ordered space which are usually used in economic models, another situation takes place:

Theorem (for proof see [6]). If M is an ordered vector space with a "strict" order (no equivalence is allowed) for which the Axiom of Archimedus is false, then there does not exist any utility function.

That means that for any Eucledean space with usual topology (born by metric) there exists no utility function for a "strict" order. If we still want to deal with it (for instance in the case of a model of production of, say, goods) we should use the so-called "equivalence curves", (that is, a set of goods which are not prefered to each other). It is obvious that doing this well we would be able to construct a utility function (this procedure simply means that Archimed Axion is now true).

If we consider Ramsey's problem, the maximization of cumulative consumption over an infinite time horizon $U(c) = \int_0^\infty u(c,t)dt$, we can notice that it is actually a problem of finding the best $c(t)$, the consumption strategy from a set $C = \{c(t)/c(t) \geq 0\}$ where time t can be either continuous (and then C is a subset of vector space of infinite dimension) or discrete (then C is a subset of Eucledean space of finite dimension). From the theorem mentioned above follows that if we want to construct $U(c)$, - utility function, on C, we must artificially introduce "equivalent curves" which we consider to have no foundations at all.

(3) In a number of works a model based on the assumption that a man in a decision-making position behaves so that if he does not know the exact values of the parameters of the problem under consideration, it is useful for him to choose a strategy which--with any realization of the parameters (with unknown probabilities)--minimize the possible loss resulting from the man's action.

This is called the "minimax" principle. This assumes that a man assesses losses higher than gains. But (and it has often been pointed out) there do not exist many people who would always pursue this overcautious strategy; as usual, man's behavior is a mixture of risk and caution, which enables him to survive and shows in different situations more or less the level of risk aversion.

The drawbacks of this model are visible in situations where there is a big gap in absolute values between losses and gains; in these cases the minimax rule leads to absurd results. In a number of cases the statistical minimax estimation was worse than the estimation found with the help of the usual statistical methods, as Savage points out in "Foundations of Statistics."

We should note that in some works it was stated that the minimax principle is not a normative principle but is descriptive. Let us consider the system of axioms proposed by Vilkas [11]. Let F be the real function on M, a set of all finite-dimension matrices such that:

C1. If A_1 and A_2 from M and for all i and j, then $a_{ij}^{(1)} \geqslant a_{ij}^{(2)}$ then $F(A_1) \geqslant F(A_2)$.

C2. If $\bar{A}$ is A with one more added row, which does not exceed any convex linear combination of rows of A, then $F(\bar{A}) = F(A)$.

C2[1]. If $\tilde{A}$ is A with one more added row, which is not less than any convex linear combination of rows of A, then $F(\tilde{A}) = F(A)$.

C3. If A^T is transparent A, then $F(-A^T) = -F(A)$.

C4. Becuase any real number x is a matrix dimension 1x1, then $F(x) \geqslant x$ for all x.

C4[1]. $F(x) = x$ for any x.

<u>Theorem</u>. F(A) which satisfied C1, C2, C3 and C4 or C1, C2[1], C3 and C4[1] is equal to the value of the game based on the minimax principle (see [11]).

Let us consider the meaning of these axioms. C1 states that the granted gain will not become less if gains do not become less in all possible games. Of course, this is only in the case when we aquired information of the inequality $a_{ij}^{(1)} \geqslant a_{ij}^{(2)}$. But in real problems it is useful to consider the elements a_{ij} of A to be the "values" (prices) of some set b_{ij} of objects (that is, $b_{ij} = f(a_{ij})$). But if a dimension of A is large enough during the comparison elements of A1 and A2 (for C1), values "f" might change greatly. Of course, someone might say that the computer can compare them faster. But to my mind, the description of man's behavior with the assumption of the computer's existence is useless--in real problems such as policy-making, management, military problems, sports, etc., man has to make decisions with uncertainty and with limited resources (time, money, etc.) in order to aquire the required information.

But decisions are still made and one can only improve them by means of acquiring new information. Therefore it is necessary to study the human decision-making process without assuming that one can always have all information.

C1 and $C2^1$ state that obviously "bad" strategies could be excluded beforehand. But all these restrict the set of all possible strategies a priori, and one can note that C2 and $C2^1$ are "masked" minimax rule (they are well-known in the theory of games as rules of omitting dominant row or column).

C3 expressed the antagonism of players in a matrix game and shows that gains of both are inequal in absolute values and opposite in sign. But as shown by Savage, such an expression of antagonism has some drawbacks (and moreover in "games with nature" the antagonism does not take place, and it was those games where the minimax rule is applied most often).

This all infers that the model of decision-making behavior based on the minimax rule is also a normative model.

CONCLUSION

In the present work we dealt with the problem of taking into account the human factor in the decision-making process. We tried to show that at present existing theories of decision-making use elaborated, sophisticated mathematical tools, (which comprise only normative theories) and which in a number of situations lack solid base and cannot help a manager to make decisions because they omit the human factor completely. We offered some primitive models of decision-making which can, even on this level of precision, show the weak points of existing theories. Of course, a lot of future work is needed to construct a really descriptive theory of decision-making.

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