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Progress and Trends in Operational Research

Operational research has a vast field of application. However, too little has been achieved so far to find out the common structure of the problems liable to be treated through operational methods.

The endeavour to more strictly define the sphere of operational research, to set its limits from the adjacent disciplines and to assign it an independent place among the modern and applied sciences is not only a simple semantic exercise. The effort devoted to it in the field of research activity and, in a way, its aptitude to progress at a rate corresponding to the weight it carries in applications and in the development of other sciences, are dependent on its degree of independent ripening.

One of the youngest branches of applied mathematics, operational research, continues to be a collection of methods gathered together under an improper name. Although Archimedes could be considered as the founder of this science, for the reason of having used mathematical means to defend Syracuse, operational research is more recent. Mathematical models in economy have been utilized disparately already before the Second World War, and statistical methods in production management have been applied concomitantly with the modern development of industry. The last war, demanding the mobilization of all available resources, has drawn all the branches of mathematics towards solving the problem of the optimum mode of action. The resulting collection of methods was treated as a confidential item, in the same manner in which descriptive geometry had remained for many years a military secret on account of the fact that its founder, Gaspard Monge, was an officer in the engineer corps.

At the end of the war all the methods of operational research were rapidly transferred to the domain of industrial production. The consequence was of such importance that numerous authors now attribute the preponderant

part in the spectacular increase of production and services, to the factor constituted by the mathematical methods of organization and management.

Notwithstanding their position and acknowledgement, the methods of operational research did not make up a new organic discipline. To satisfy the classical criterion of a science they should have been able to define their own object, methods and laws. However, operational research has a vast field of application. Too little has been achieved so far to find out the common structure of the problems liable to be treated by operational methods. Proceeding from several domains they, in their turn, consisted of apparatuses and procedures of great diversity. Under these circumstances, almost every author has given another definition to operational research. Some are reconciled to the idea of seeing in it a simple collection lacking a name or a final status, a list of procedures suitable for applications, taking a collateral advantage from the results of the important branches of mathematics: algebra, calculus of probabilities, mathematical logic and analysis. However, the predominant current endeavours to define the unifying element of those mathematical methods and to hasten their crystallization into an independent discipline.

Indeed, the common elements of the methods of operational research are considerable in number. In the first place, all of them refer to problems having a great or an infinite number of possible solutions. The methods of operational research offer the procedure of selecting, from the space of possible solutions, a single solution satisfying one or several fundamental conditions. This is the optimal solution. By supplying the procedure of selecting the optimal solution, operational research becomes a precious aid of decision. Many authors call it "scientific preparing of a decision", and suggest *decision* as the unifying concept. Although it plays an important part in operational research, decision is a particular moment of a broader process in which three elements take part: objectives, resources and strategy. Decision has the disadvantage of emphasizing an outer aspect of the phenomenon.

The following question can be found in all the methods of operational research: *how* (by what strategies) *must the resources be set, in view of reaching* (in the best conditions) *certain objectives*? But, this is only another definition of *organization.* The constitution of systems made up of interdependent parts, which must satisfy certain functional requirements (objectives), in optimum conditions, is the vocation of organization. Thus, the methods of operational research are nothing but the bricks of an edifice of the *science of organization.* To do away with the qualitative legacy of this word, it is not useless to try and find a new name for it. We could name the science of organization, *teinology*, from a Greek verb which means to place in a determined situation. In contrast with technology, which represents the totality of methods and procedures for material processing, teinology would be the science of the organization of the factors concurring to the constitution of a system.

Besides the domain of an economic, financial, commercial nature and of the organizing of modern production, the science of organization is called to support biology, sociology, psychology, history, the study of relations among individuals and among states, and the situations of conflict and co-operation. Therefore, in our opinion, it is inadequate to speak about *economic mathematics*, in the sense that the same apparatus is also used for sociologic or for biologic mathematics, and so on.

The methods of operational research are suited for a simple division in three basic categories. The first is centered round *linear programming*. This simple model offers the greatest number of applications, where both the constraints and the function objective are linear. In case the function objective is quadratic, programmation becomes quadratic. Finding the pure and the mixed strategies in matrix sets reduces to linear programming.

The graph theory in its most frequent problems of minimum path or of maximum flow leads to a problem of linear programming or to its extensions. One remains, here, within the same family of methods for which algebra constitutes the most important source. If the first category of methods is useful to the optimal organization of a system or to its internal study, having a pronounced deterministic character, the second class of methods deals with the behaviour of the system in the presence of random external stress. It is dominated by the calculus of probabilities. The older models of the statistical control of quality, the equipment, inventory and queueing theories which are more recent, belong to this section. Its methods find their application in the maintenance problems of a system subject to a number of factors that vary at random (customers, sales, machine break-down, staff fluctuation, etc.).

The third category is made up of the instruments which study the structures in their reciprocal dependency. The mathematical logic, information theory and theory of automatic mechanisms, are the branches which approach, from various angles, the study of structures.

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Operational research is the object of intensive exploration in various countries. There are departments devoted to these methods, under various denominations, attached to the universities; academic institutes and research centres devote considerable efforts of investigation to them. Various associatons and societies aim at spurring and co-ordinating them. In France, *l'Association française d'informatique et de rcherche opérationnelle* publishes a journal bearing the same title, in Great Britain the *Operations Research Society* has been acting since 1948, with the publication "Operational Research Quarterly", and in the U.S.A., since 1952, the *Operations Research Society of America* with its Journal. In the Soviet Union the centres of cybernetics, in Kiev, and of telecontrol and automation, in Moscow, as well as the laboratory of mathematical research in economy, in Leningrad, are well known.

Starting with only three members, the *International Federation of Operational Research Societies* (IFORS) now comprises more than twenty member societes. However, international co-operation in this field is only at its beginning. In the domain of calculus, more advanced forms exist, such as the International Computation Centre in Rome.

In Romania, where the school of algebra and of probabilities enjoys a respectable tradition, the present literature devoted to the methods of linear and non-linear programming, to the theory of games and to the statistical methods, is rich and varied. Every year the scientific session of the Centre of Economic Computation and Economic Cybernetics gathers together the most important results obtained in applying mathematical methods to the develop-

ment of national economy. The research workers of the Institute of Mathematics and those of the Centre of Mathematical Statistics of the Romanian Academy, those of the Centre of Economic Computation and Economic Cybernetics and those of the Centre for Advanced Training of the Managing Staff in Enterprises take part in international conferences and congresses and maintain relations of co-operation with the research workers of other countries. In February 1969, at a meeting of the experts of the UN economic commission for Europe, they suggested the creation of a European centre of operational research, under the sponsorhip of the United Nations.

International co-operation is meant to support the research work undertaken on a national scale and to hasten the turning of the group of methods of operational research into a distinct mathematical branch.

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In a first stage of computer development, stress was laid on their technology, called *hardware*. The progress achieved in computer building and their advanced technical performance have then focused attention on *software*, on programs. In this domain too, the automatic and semi-automatic languages and the systems of data processing are about to offer all the resources contained in software. Computer efficiency is not exhausted by these two categories. Fast computers and advanced programs both need algorithms suited for calculus as well as instruments for mathematical modelling, created by the mathematical science of organization. In this sense a new category — *fineware* — may be mentioned, called to offer its contribution to broadening the field of application of mathematics and to improving research in the economic, biological and social sciences.

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PROGRES ET TENDENCES DE LA RECHERCHE OPERATIONNELLE

Les méthodes de la recherche opérationnelle ne constituent pas encore une discipline organique et il a été fait trop peu jusqu'ici pour mettre en évidence la structure commune des problèmes susceptibles d'être traités par ces méthodes. Selon l'auteur, les méthodes de la recherche opérationnelle permettent de choisir entre toutes, la meilleure solution, celle qui répond à une ou à plusieurs conditions essentielles. Ces méthodes se prêtent à une division simple en trois catégories fondamentales: 1) programmation linéaire; 2) théorie des graphes; 3) instruments

d'étude des structures dans leur dépendence réciproque. Partant de cette classification, l'auteur propose la création d'une science indépendante: la *teinologie.*

On estime en même temps que, pour l'utilisation efficace des ordinateurs, il est nécessaire de développer le *fineware* c'est-à dire les algorithmes pouvant être utilisés pour le calcul et les instruments de modelage mathématique

ПРОГРЕСС И ТЕНДЕНЦИИ В ОПЕРАЦИОНАЛЬНОМ ИССЛЕДОВАНИИ

Методы операционального исследования до сих пор не образовали органическую дисциплину, и очень мало сделано, чтобы выявить общую структуру вопросов, которые можно рассматривать как восприимчивые операциональный метод. По мнению автора, методы операционального исследования дают возможность выбора из пространства решений одного единственного — оптимального, удовлетворяющего одно или больше из основных условий. Эти методы сводятся к простому разделению на три основных категории: 1) линейное программирование; 2) теория графов; 3) инструменты изучения структур в их взаимозависимости. Исходя из этой классификации, автор предлагает создание самостоятельной науки: *тейнологии.*

Также, подчеркивается, что для эффективного употребления счетных машин необходимо развивать fineware, то есть, особенно хорошие расчетные алгоритмы и инструменты математического моделирования.