

PROGRESS IN OPERATIONS RESEARCH

Volume II

edited by

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and

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PREFACE

Operations research literature has been growing by leaps and bounds. This volume is intended to consolidate and review this literature in specific areas of application. It follows the excellent "Progress" volume edited by Russell L. Ackoff, published in this series in 1961, which was devoted to exposition of technique, methodology, and philosophy. Hopefully, as operations research continues to grow and the application of management science to problems expands, we will be reaching not only the audience anxious to receive information of a technical nature, but also those who would like to have an overview of the uses of operations research.

Based on the fine reception to the first "Progress" volume, it is the intention of the Operations Research Society of America to continue this series, alternating between volumes concerned with methodology and technique and volumes concerned with application.

The Editors of this volume and the Council of the Society agreed that we would try to bring together viewpoints of the literature on an international basis. To do this, it was decided to select chapter authors from as many countries as possible within the limitations of professional experience in the field. In this aim we have been successful in that there are nine authors from the United States, five from the United Kingdom, two from France, and one from Canada. All have been in the forefront of applying operations research in the area in which they were asked to write. All were given a free hand in bringing to the attention of the reader both review and critical material. There are chapters on the major functional elements of a business and the major industrial and governmental categories. We are well aware of omissions. We had hoped to cover the whole of operations research applications to world enterprises and their management. It was not

possible, however, to obtain authors for every chapter envisioned. Perhaps future volumes can make up for current deficiencies.

We would like to express our appreciation to each of the contributors for their cooperation in the development of this volume and to those who helped by reviewing each of the chapters published. The names of the helpful reviewers are cited elsewhere. This volume, of course, owes a great deal to the Publication Committee and Council of the Operations Research Society of America, without whose support it could not have been published.

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Chapter 1

**APPLYING OPERATIONS
RESEARCH IN INDUSTRY
AND GOVERNMENT**

ROGER T. EDDISON AND

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Those who are most disdainful of theory unwittingly earn their daily bread from it; deprive them of it, and progress would soon come to an end.

—*Henri Poincare in LA VALEUR DE LA SCIENCE*

1. OPERATIONS RESEARCH AT WORK

The first volume in this series was concerned with the technical progress of operations research, or, as Russell Ackoff put it in his introduction, “the techniques of model construction and of deriving solutions from these models.” The chapters in this volume, instead, describe a body of knowledge that applied operations research workers have accumulated about applications of models to solve problems of business and government.

In 1962 the Council of the Operational Research Society of the United Kingdom published the following official definition of operations research:

Operational research is the attack of modern science on complex problems arising in the direction and management of large systems of men, machines, materials, and money in industry, business, government, and defence. The distinctive approach is to develop a scientific model of the system, incorporating measurements of factors such as chance and risk, with which to predict and compare the outcomes of alternative decisions, strategies, or controls. The purpose is to help management determine its policies and actions scientifically. [*Operational Research Quarterly*, Vol. 13, No. 3, 282 (Sept. 1962).]

In the 25 years during which operations research has been used its nature has become clear—it is scientific method applied to the construction of predictive models. Stafford Beer noted, in 1959, that “operations research is not a science, for it is not *about* anything; it is science” (*Operational Research Quarterly*). However, it is becoming increasingly apparent that, at a deeper level, operations research has to do with the organization of social decision making: the information, the manipulations of data, and the methods of evaluation that are used to maintain or change the activities people undertake. It also begins to be clear that operations research has had a profound influ-

ence on the nature of decision-making processes. This influence is possibly greater and more subtle than any of us are yet in a position to judge, even though much of what we read in this volume suggests many deficiencies in the use of problem-solving models. Indeed, these very suggestions that operations research could be used more effectively are indicative of the changes that have occurred. The way in which people think about decisions and the institutional context in which they operate have been changed because the OR worker has devoted his attention to the meaning and implications of the total process.

2. THE PLAN OF THIS BOOK

In using operations research it is not enough to know how to construct a model; the model has to be constructed for a specific decision-making process in a specific institutional context. This book is intended to give a picture of the progress of operations research in terms of areas of application and depth of penetration.

The authors were asked to review the state of operations research applied to functional areas of business and industry, and to review the status of OR in major industries.

The chapters on functional areas (such as marketing and sales, management information systems, production, and distribution) are intended to provide a comprehensive and integrated survey of the contributions operations research has been able to make in the specific field, drawing on source material from whatever industrial context is appropriate.

The industry reviews (metals, petroleum, mining, etc.) are short statements of the status of operations research in various industries with related literature references. These reviews are shorter because it was felt that the OR community would be less interested in a specific industry (e.g., steel) than in a function—say, production control (the latter may, however, draw on an example from the steel industry). Therefore, these shorter reviews were to assess progress in various industries succinctly and critically and perhaps indicate paths opening up for the future.

Thus we have chosen to classify the fields in which the applied operations researcher works from two different points of view: the institution and its morphological components. In doing so we have followed the traditional classification of political and social science. Here we are on sound ground, for operations research can serve as

science for political action directed at social change. Like most branches of social science it draws from and contributes to many related fields. Rooted in mathematics, economics, engineering, and the physical sciences, it deals increasingly with problems related to psychology, anthropology, sociology, and public administration.

The chapters that follow, though they present material related to all these fields, nonetheless show that operations research has characteristics that cannot be attributed to any one of them. An operations researcher, working in a functional activity, say production scheduling, will attempt to sort out the key decisions that lead to significant costs or benefits and then construct a predictive model around these key points, drawing on models developed for other production scheduling problems in many industries, and taking into account the social surroundings that prevent the decision maker from simply choosing any path of action he pleases. Similarly, the OR specialist working in an industry, say steel manufacture, attempts to analyze the decisions that are particularly significant in this industry and find productive ways of improving the total process, whether in one functional area or another.

Therefore, statements of progress in application are properly statements of what has been done in industrial and governmental contexts, and what has been accomplished in operating activities.

3. HOW PROGRESS IS DESCRIBED

Although this volume does not set out to be a textbook of OR techniques, the techniques used and their development are necessarily mentioned. The reader can find more detailed information on techniques by consulting the extensive bibliographies of each chapter.

References to techniques in the text indicate that general statistical techniques—including sampling, probability, and forecasting—are the most frequently applied; next in popularity is simulation, which is mentioned in a high proportion of chapters. The various forms of mathematical programming are also popular; problems involving network analysis and routing are less frequent.

The toilers in the fields of application have apparently found OR philosophy of little help in solving specific problems. Of course, this is to be expected in any field. However, though the importance of the total systems approach is mentioned, many problems appear to be fragmented in nature. For example, although sales are frequently mentioned as an area of study, we are clearly still far from the stage of being generally able to attack as a whole a company's total prob-

lem—from purchasing of raw material, through production and distribution, to selling and customer satisfaction. It is perhaps significant that the attempts to do this are most prevalent in what may be regarded as the ancillary departments, such as transportation and stock control. This shows what can be done, when a central problem is recognized, to break down the barriers between the traditional production and commercial departments. Operations research should develop to take fuller advantage of such situations; meanwhile it must be admitted that many intradepartmental problems are still big enough and contain enough dead wood that must be cleared away so that the scope of applications of operations research is quite broad, even though a total approach may someday be possible.

Among the areas of interest revealed here, pride of place appears to go to problems in costing and in deciding criteria of choice. Fixed, variable, and marginal costing; opportunity costs; capital investment allocation in budgets; measures of effectiveness; welfare economics; all come in for discussion. Price elasticity of demand (and supply) received little attention in spite of the considerable development indicated in the application of operations research to sales and purchasing. It is not unexpected to find that the problem areas most frequently mentioned involve studies of capacity, flow, and transportation. Load-factors, queues and congestion, networks and scheduling stock control, maintenance and renewal, and warehousing all occur frequently.

4. OPTIMIZATION, EXPERIMENTATION, AND QUALITY

A major concern of the operations researcher is: Why does not an institution's system of decision making have optimal results? If there were no constraints on decision making, would results be optimal? This, of course, can lead to concern with what optimal results are. It turns out that this is not a particular concern of those who *must* apply the system.

We may detect a considerable move away from attempts to achieve absolutely optimal results and toward aiming for improvement instead. Operations research workers have learned to accept some constraints and to work on a problem within boundaries. Identifying the constraints in some systematic way gives a notion of how much they cost in terms of attainable changes. The relativity of OR solutions has begun to be clear: The desired results must always be related to the constraints set.

In affairs of management the robustness and stability of a solution are more important than a tightrope of optimality, however clever the balancing trick; nonetheless, the search for improved aids to balancing is vital so that we can move steadily toward the peak without fear of instability; brinkmanship has its place in management as well as politics. One of the peaks to which industry is undoubtedly advancing is that of automation, and the aids to safe balancing come under the general title of controls. All this is a good field for operations research, but we as yet have few references to progress in automation or in management controls, servomechanisms, or cybernetics.

Conant has written that the distinctive feature of scientific method is experiment. However, there is little about direct experiment in these chapters; the use of models, especially simulation models, can in itself be regarded as an indirect form of experiment, but we would like to see more on the subject of testing of results. Modern concepts of statistical design of experiments were developed primarily in agricultural research, where scientists found it necessary to conduct experiments in real-life conditions. Experimental design as a subject has, of course, long since graduated into the realms of industrial research, but it is astonishing what a small part this tool plays in OR literature. If this is because OR people are diffident about using a tool that has a well-developed niche in applied statistics, it is also deplorable. There has been many an argument about problem orientation vs. technique orientation in operations research. But surely all would agree that operations research is nothing if it cannot claim to use—and indeed does not use—the appropriate technique for the job, whether that technique be drawn from applied statistics, economics, engineering, biology, or physics. The great sin is to make a little collection of special techniques, mostly mathematical, tie them together with a neat ribbon, and say “that is operations research.”

In the same vein, we cannot but remark on the dearth of reference to quality. In the long run, quality cannot be ignored in any problem relating to the total function of the firm. To do a better job or make a better product (yes—even “better” needs defining) generally costs more; it may require more man-hours; or more expensive machinery; or more process time; or perhaps more expensive material. In any planning this additional cost must be related to the resulting benefits: more safety, longer life, greater reliability, or just more beauty. And these benefits have to be evaluated first in terms of the purchaser's scale of values, then translated to the manufacturer's.

It is important to note that this has nothing to do with statistical

quality control, which is just what its name implies: a method of maintaining the quality sought once that level of quality has been determined. Statistical quality control comes into the OR equation, of course, as the efficiency of the quality control system affects the cost of maintaining a particular level of quality, but it is only a part of the whole. Still less has this anything to do with the fashionable subject of cost reduction. To reduce production costs by cheeseparing the design can be facile; if done without carefully relating it to, for example, safety, durability and reliability, it can be dangerous. Several chapters of this book indicate operations research's role in helping decide on the balance.

5. OPERATIONS AND STRATEGY

Most chapters contain some reference to strategic and national problems as well as to tactical ones. This conforms with the conception of operations research as the application of science to policy decisions; this means to strategy, and where more effectively than to national problems? But alas! most of our authors mention this aspect only to complain of how little is done at this level. There are, of course, notable exceptions; some chapters are devoted specifically to strategic and national problems. The general verdict is nevertheless clearly that operations research has not progressed as far or as fast as it should at these levels. This confirms the conclusions drawn by Stafford Beer in a recent article ("Why Government Should Investigate OR," *Automatic Data Processing*, July 1962). Of all the areas of public enterprise that operations research might contribute to, perhaps the one that comes most readily to mind is the formulation of transportation policies. Indeed, there has been some notable work on this subject, of which a most interesting example is the recent social benefit study by C. D. Foster and M. E. Beesley (*Journal of the Royal Statistical Society*, Ser. A, 126, 46-94) which led the government to decide to build a new underground line in London. Yet such appearance of progress was denied almost the next day by the failure to produce a coherent transportation policy for the whole of England.

It is perhaps pathetic that the most impassioned plea for more strategic operations research should in fact be made by A. M. Lee in the final cadences of his chapter on transportation. Let us hope that OR workers will take note of what he says. If they can seize the opportunity to think in terms of policy, there are problems in abundance crying out for their skill.