Management Science
An Introduction

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QUANTITATIVE METHODS FOR MANAGEMENT SERIES

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McGraw-Hill Book Company
New York St. Louis San Francisco Auckland Bogotá Hamburg
Johannesburg London Madrid Mexico Montreal New Delhi Panama Paris
São Paulo Singapore Sydney Tokyo Toronto

MANAGEMENT SCIENCE: An Introduction

234567890DODO8987654321

This book was set in Times Roman by Better Graphics. The editors were Donald G. Mason, Ellen R. Friedman, and Laura D. Warner; the design was done by Caliber Design Planning; the production supervisor was Charles Hess. New drawings were done by J & R Services, Inc.
R. R. Donnelley & Sons Company was printer and binder.

Library of Congress Cataloging in Publication Data

Dannenbring, David G
Management science.

(McGraw-Hill series in quantitative methods for management)
Includes index.
1. Management—Mathematical models. 2. Operations research. I. Starr, Martin Kenneth, date joint author. II. Title.
HD30.25.D36 658.4'034 80-22874
ISBN 0-07-015352-3

Glossary

Algorithm A problem-solving procedure consisting of a set of logical and mathematical operations.

Artificial variable An added variable used with the simplex method for solving linear programming problems with greater than or equal constraints, to convert an infeasible solution to one that is artificially feasible.

Assignment problem A decision problem requiring the one-for-one allocation or assignment of a set of objects, such as jobs, to another set of objects, such as machines, in the least-cost manner.

Basic variable A variable with a nonzero value for a feasible solution to a linear programming problem.

Behavior toward risk The manner in which a decision maker assesses risk when assigning utility to outcomes for a decision problem.

Bill of materials A listing of all the materials, parts, components, and assemblies that are used to manufacture a product, showing the quantity of each required to make one unit of the product.

Branch and bound A solution procedure for integer programming problems that successively adds constraints that eliminate noninteger solutions until the optimal integer solution is obtained.

Break-even volume The sales volume at which revenue and total costs are equal and net profit is zero.

Capital budgeting problem A decision problem requiring the selection of a set of investment projects that yields the best return without violating financial and other resource constraints.

Central limit theorem A statistical theorem that the distribution of the sums of a large number of samples of random variables will be approximately normal, regardless of the type of distribution for the random variables.

Constraint A restriction imposed on a decision problem that eliminates certain decision alternatives.

Correlation The interdependence or relationship between two variables.

Crashing Shortening the time it takes to complete an activity of a project by assigning additional resources to that activity.

Critical activity A project activity that if delayed will cause the entire project to take longer than expected to complete.

Critical path method A procedure for identifying the critical activities and expected length of a project.

Data base A structured collection of data for an organization, often including information about present and past operations.

Decision alternative An alternative decision option or strategy that can be selected to achieve objectives for a decision problem.

Decision criterion A logical or rational rule for selecting the best alternative or strategy for a decision problem.

Decision model A framework for conceptualizing a decision problem that consists in identifying the objectives, strategies or alternatives, and uncontrollable events, measuring the outcomes and event likelihoods, and applying a decision criterion to select the best alternative or strategy.

Decision tree A graphical treelike means of organizing and presenting the various elements of a decision problem.

Decision variable A decision alternative, or part thereof, that requires the specification of a level or value, such as the amount of money to be spent on advertising.

Degeneracy A condition that can occur with linear programming problems in which three or more constraints are simultaneously satisfied by a feasible solution.

Departing variable The basic variable that will become nonbasic as the linear programming simplex method moves from one feasible solution to the next.

Dependent demand Demand for parts, raw materials, etc., that is determined by or dependent on requirements for end items or products and can therefore be calculated rather than forecast.

Descriptive model A management science model that can be used to provide a description or prediction of outcomes likely to occur as the result of specific alternatives but is not suitable for use in determining the optimal alternative analytically.

Deviational variable A goal programming variable whose value measures the degree by which a specific goal is over- or underachieved.

Dual An alternative formulation of a linear programming problem that can be used to provide additional insight, interpretation, and sensitivity analysis for the optimal solution.

Dynamic programming A conceptual approach or solution strategy that can be used to solve prob-

lems involving a set of sequential, interrelated decisions.

Economic order quantity The size of a replenishment order that will minimize costs associated with ordering and carrying inventory.

Entering cost The amount by which the objective function for a linear programming problem will decrease as the result of a one-unit increase in the value of a nonbasic variable.

Entering variable The nonbasic variable that provides the largest improvement in the objective function of a linear programming problem for a one-unit increase in that variable. This variable will become basic in the next solution and is thus said to enter the set of basic variables.

Equilibrium shares Long-run market shares that would result from a given set of brand-switching probabilities for a Markovian model of consumer buying behavior.

Expected value Weighted average outcome for a specific decision alternative where the weights are the probabilities of occurrence for each uncontrollable event.

Expected value criterion A decision criterion used for problems of decision making under risk. This criterion specifies that the alternative with the best expected value should be chosen.

Explanatory forecasting model A forecasting model based on hypothesized or observed relationships between the variable to be forecast and a set of explanatory variables which are thought to influence changes in the forecasted variable.

Exponential smoothing model An extrapolation forecasting model that uses an exponentially weighted average of past observations to forecast future observations.

Extrapolation forecasting model A forecasting model that uses historical data for the variable to be forecast and possibly past forecast errors to project or extrapolate to the future.

Extreme point A feasible solution to a linear programming problem that exactly satisfies two or more constraints; graphically, the corner points of the feasible region.

Feasible solution A solution to a decision problem that satisfies all problem constraints.

Feedback A process of obtaining information comparing actual with planned performance in order that changes can be effected to reduce the deviation of actual from planned.

Finite source model A descriptive model of a service system in which the number of potential arrivals is finite and, in practice, relatively small.

Forecast error The difference between forecast and actual values.

Forecasting model Any of a variety of structured models used to provide forecasts.

Goal programming A specialized procedure that can be used to solve linear programming problems with multiple objectives.

Graphic model A pictorial or graphic representation of a management science model.

Heuristic A procedure, often based on good judgment, which is used to generate satisfactory solutions to decision problems but which cannot guarantee that such solutions are optimal.

Inequality A mathematical expression that requires one side of an equation to be not less than the other side. One of the ways in which inequalities are used is to model constraints in linear programming problems.

Integer programming problem A linear programming problem for which some or all of the decision variables are restricted to be integer or nonfractional values, and sometimes further restricted to be either zero or one.

Inventory model A management science model used to minimize the costs of maintaining and replenishing an inventory. Such models are usually concerned with the size and timing of inventory replenishment decisions.

Limited waiting capacity model A descriptive model of a service system in which customer waiting room capacity is finite.

Linear programming problem A decision problem requiring the determination of values for decision variables that optimize an objective without violating a set of constraints. Such problems normally involve resource allocation and always involve linear relationships between the decision variables, the objective, and the constraints.

Lumpy demand models Inventory models for items that have lumpy or nonuniform demand.

Management decision support system A management information system that incorporates management science decision models with solution capabilities to provide optimal or satisfactory heuristic solutions.

Management information system A system encompassing the collection, maintenance, and use of information for organizational purposes.

Management science The application of scientific methodology, or principles, to management planning, control, and decision problems.

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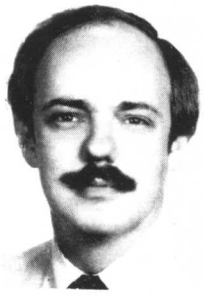
About the Authors



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Preface

We begin this Preface by stating the obvious: There are numerous introductory management science texts. Yet many of our colleagues express dissatisfaction that there is no one *adequate* text. We set ourselves the goal of determining what is wanted—by most instructors—and then writing that book. Simply stated, what we believe is wanted is breadth of coverage, achieved at a relatively high and uniform level, but always accessible to beginners (no linear algebra or calculus prerequisites) by means of patient and detailed explanation which uses examples.

Design of the Book

The main differences in teaching approaches are by level and by division of materials. By level, our book occupies a unique position. It is designed to eliminate the effect of variability in student capabilities and motivation. Starting at the simplest level, it then stretches idea development and application to near the top of what is available in the text market. It does this for the broadest range of topics (as the Table of Contents indicates). The instructor can control the level, for any particular topic, by assigning a continuous sequence of pages with a cutoff when the level exceeds the course objectives. In other words, as development moves from simple to complete, there are no discontinuities requiring page-jumping.

For example, decision trees are first introduced at the conclusion of Chapter 2, for simple, single-stage problems. Sequential, multiple-stage decision trees are not treated until Chapter 3. Those instructors who require only a brief introduction to the use of decision trees can assign Chapter 2, omitting Chapter 3; those who wish to provide a more thorough treatment can assign both chapters; and those who prefer to skip coverage of decision trees can omit the last section of Chapter 2 and all of Chapter 3. No matter which choice is taken, the flow of the rest of the book is not disturbed.

Similar nondependent modularity is provided for many other topics in the book. Where possible, major topics have been subdivided into several chapters. For example, linear programming is covered in four chapters, decision analysis in three chapters, forecasting in two chapters, and inventory in two chapters. Where single chapters are used, we have attempted to organize the material with the more complex topics at the end so that they may be omitted, if the instructor so desires, without loss of continuity.

The division of materials differs among various schools. The typical breakdown is:

One-third programming, especially linear programming
One-third decision analysis
One-third miscellaneous topics (queuing, inventory, simulation, etc.)

Our book is structured to match the usual breakdown but, because of its breadth and attention to the patient development of all topics, the percentage of these divisions can be changed more easily than with other books. This meets the often expressed desire of our colleagues to have topical flexibility for matching course content with course objectives and student profiles. Thus, with this text, programming can readily be increased to about two-thirds of the course coverage. Similarly, decision analysis or miscellaneous topics can be accorded greater attention. In addition, miscellaneous topics can include separate chapters on heuristic programming, goal programming, forecasting methods (two chapters), simulation, and management information systems (MIS).

Chapters can be included and excluded as modules to satisfy different course plans. We believe that the extent to which our chapters are modularly structured is a unique feature of this text, as is the ease with which topical sequence can be altered. For example, decision making may follow or precede mathematical programming, without the awkward disruptions that can accompany chapter assignments made out of order.

Special Features

One of the most crucial goals we addressed was text readability for beginning students. We accomplish this by carefully explaining the nature of the problems that are tackled and resolved by each method. Using illustrative problems, we develop a conceptual basis for understanding each different topic. In the three categories of programming, decision analysis, and miscellaneous topics, we provide a great variety of problems. All of them deal, in one way or another, with utilization of resources. But the specific kinds of application (e.g., blending, inventory levels, service capacities) must be understood by students if they are to be motivated to read and understand the text material. We explore each of the diverse problem areas in detail, concentrating on relating problem solving to the realities of the appropriate managerial situation. With an understanding of why a problem exists, and how it relates to real management situations, students are motivated to study a new method that can resolve the problem.

We assiduously avoid viewing our world as techniques in search of a problem. Nor do we wish to enter competition for achieving mathematical elegance, by which we mean providing brief and terse explanations of ideas. We have instead tried to close every gap of understanding with patient, detailed explanation. The use (throughout the text) of examples to explain methods makes it difficult indeed to fall into the math language trap. Yet even difficult topics, such as integer and goal programming, are fully comprehensible to the students.

Throughout the text, particularly where the going may be tough for the students, Instant Replays are introduced. These are problem variants requiring new calculations of what was just explained. With answers provided, the Instant Replays generate self-checking feedback to the students about their comprehension of the material.

Numerous problems at the end of each chapter cover all areas of management, including both the profit and not-for-profit sectors. There are manufacturing-, service-, and government-focused problems. To assist students who are concentrating in various functional areas, the problems treat issues in

finance, marketing, production, accounting, personnel, and so forth. (The Instructor's Manual provides information helpful in selecting problems for assignment, including an assessment of each problem's difficulty.)

The in-text examples are worked out in detail. Six case studies are presented as end-of-chapter supplements, providing application descriptions of material covered in the text. Computer applications are attached whenever feasible. Instructors can include these, or not, depending upon course objectives. Key words are listed at the end of each chapter, and a glossary is provided inside the front and back covers. Each chapter concludes with an overview of the material covered. Each overview takes a managerial perspective rather than simply recounting the text material.

Organization of the Book

The book is divided into six parts and 21 chapters. Although most of the topics covered will be quite familiar to instructors, there are several features that we feel deserve specific mention. Chapter 1 provides the framework for the management science process and walks the student through a simple example. By discussing the relationship of management science to the manager, with specific examples of successful applications, we attempt to build the students' motivation. Part One (Chapters 2 through 4) provides a comprehensive presentation of the use of management science in decision making. Of particular note is the inclusion of multiple-objective decision problems in Chapter 4.

Part Two, which includes Chapters 5 through 8, addresses linear programming problems and methods. From the beginning, students are shown how to use the computer to solve linear programming problems, including how to interpret output. Chapter 8 focuses on the use of goal programming to handle problems with multiple objectives.

Part Three (Chapters 9 and 10), provides a comprehensive review of general network flow problems, including transportation, transshipment, assignment, and minimal spanning tree problems. Part Four surveys other programming methods, such as integer programming (Chapter 11), dynamic programming (Chapter 12), and heuristics (Chapter 13). We feel that students will particularly enjoy the coverage of heuristics because it presents an opportunity for them to be creative in designing their own heuristic methods.

Inventory models are covered in Part Five, where Chapters 14 and 15 treat the traditional EOQ models and safety stock concepts, as well as considering computerized applications. A thorough discussion of material requirements planning is provided, including a review and comparison of heuristic ordering rules. Part Six (Chapters 16 through 20) concentrates on a broad variety of models used for making predictions. Chapter 16 covers the use of PERT/CPM for project planning and control. Chapter 17 reviews the use of waiting line, or queuing, models. Chapters 18 and 19, which examine the use of forecasting models, are certain to be of practical interest to almost all students. Chapter 18 treats extrapolation forecasting models, including moving average and exponential smoothing models. Chapter 19 reviews the use of explanatory models and includes regression and Markovian models. Chapter 20 covers simulation and contains three examples as well as a discussion of validation, experimental design, and analysis of results. The final chapter addresses MIS (management information systems), the organized data files that feed the management science models from inception to resolution. Often, the first part of the management science study is to define data needs.

Because of the previously described modular structure of this book, it can be used effectively for a one- or two-term sequence. In business schools, the level can be adjusted to be uniform for undergraduates above the freshman level, for graduate students at the basic introductory level, and also for an advanced elective. Industrial engineering courses span the same undergraduate and graduate levels. This text has been designed for repeat usage. It is our expectation and hope that experience with our text will provide much information about how to employ it more effectively the next time.

Text Supplements

We have taken special care to provide supplemental tools that will assist the instructor in using this text. The Instructor's Manual contains a number of features worth highlighting. Fully worked-out solutions, rather than just the final answers, are given for all problems. As mentioned above, we also provide helpful hints in selecting problems for student assignments. These include a brief description of the problems, an assessment of their level of difficulty, opportunity to modify problems, and connections between problems within a chapter or between chapters. In addition, we provide a bank of potential examination problems complete with solutions.

Sample course outlines are also included in the Instructor's Manual, and we have provided, on a chapter-by-chapter basis, suggestions and ideas for teaching the material based on our own experience. Where appropriate, we recommend supplemental readings. For those who wish to use case materials, we have identified a number of cases for potential student assignment, including those available in published case books as well as those from other sources such as the Intercollegiate Case Clearing House.

Another important supplement accompanying this text is a Study Guide designed to help students measure their progress by immediate feedback. The Study Guide contains an outline of important points for each chapter of the text, plus a variety of objective questions and short problems. Answers to the questions and problems are provided to help students in a prompt self-evaluation of their understanding of significant subject matter in each chapter.

Acknowledgments

We want to thank our reviewers. They were positive about our book, given that we address the weaknesses. We have tried our best to do this. Our appreciation goes to Milton Chen, San Diego State University; John J. Dinkel, Penn State University; John Fisk, SUNY at Albany; Janet C. Goulet, Wittenberg University; Edgar Hickman, University of South Carolina; Gene B. Iverson, University of South Dakota; Fred R. McFadden, University of Colorado; Grover Rodich, Portland State University; and George Schneller, Bernard Baruch College. Special acknowledgment is due Don Chatham of McGraw-Hill, who got us started; Don Mason, who helped us finish; and Ellen Friedman, who kept us on track throughout. Ellen's encouragement and many useful suggestions have had a measureable impact on the final product. We also wish to thank Laura Warner, Gail Hughes, and Celeste Thompson for their help and bright spirits.

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