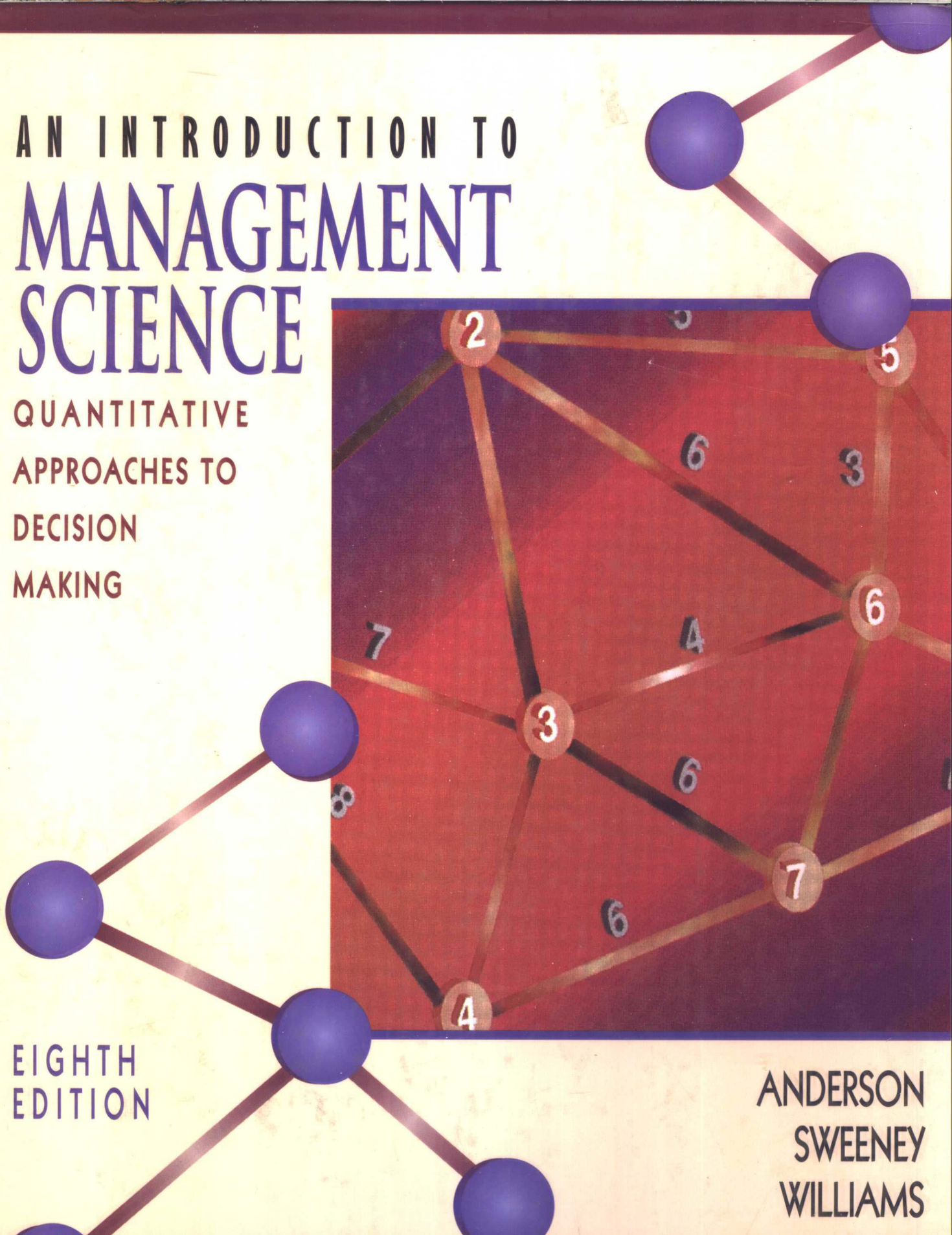
AN INTRODUCTION TO MANAGEMENT SCIENCE

QUANTITATIVE APPROACHES TO DECISION MAKING



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eighth EDITION

An Introduction to Management Science

QUANTITATIVE APPROACHES TO DECISION MAKING

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An Introduction to Management Science

About the Authors

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At the University of Cincinnati, Professor Anderson has taught introductory statistics for business students as well as graduate level courses in regression analysis, multivariate analysis, and management science. He has also taught statistical courses at the Department of Labor in Washington, D.C. He has been honored with nominations and awards for excellence in teaching and excellence in service to student organizations.

Professor Anderson has coauthored seven textbooks in the areas of statistics, management science, linear programming, and production and operations management. He is an active consultant in the field of sampling and statistical methods.

Dennis J. Sweeney Dennis J. Sweeney is Professor of Quantitative Analysis at the University of Cincinnati. Born in Des Moines, Iowa, he earned a B.S.B.A. degree from Drake University, graduating summa cum laude. He received his M.B.A. and D.B.A. degrees from Indiana University where he was an NDEA Fellow. Since receiving his doctorate in 1971, Professor Sweeney has spent all but 2 years at the University of Cincinnati. During 1978–79, he spent a year working in the management science group at Procter & Gamble; during 1981–82, he was a visiting professor at Duke University. Professor Sweeney served 5 years as Head of the Department of Quantitative Analysis and 4 years as Associate Dean at the University of Cincinnati.

Professor Sweeney has published over 30 articles in the general area of management science. The National Science Foundation, IBM, Procter & Gamble, and Cincinnati Gas & Electric have funded his research, which has been published in *Management Science, Operations Research, Mathematical Programming, Decision Sciences,* and other journals.

Professor Sweeney has coauthored seven textbooks in the areas of statistics, management science, linear programming, and production and operations management. His work with Procter & Gamble received an award in the 1996 Edelman competition sponsored by INFORMS.

Thomas A. Williams Thomas A. Williams is Professor of Management Science and Team Leader for Decision Sciences in the College of Business at Rochester Institute of Technology. Born in Elmira, New York, he earned his B.S. degree at Clarkson University. He did his graduate work at Rensselaer Polytechnic Institute, where he received his M.S. and Ph.D. degrees.

Before joining the College of Business at RIT, Professor Williams served for 7 years as a faculty member in the College of Business Administration at the University of Cincinnati, where he developed the undergraduate program in Information Systems and then served as its coordinator. At RIT he was the first chairman of the Decision Sciences Department. He teaches courses in management science and statistics, as well as more advanced courses in regression and decision analysis.

Professor Williams is the coauthor of eight textbooks in the areas of management science, statistics, production and operations management, and mathematics. He has been a consultant for numerous Fortune 500 companies and has worked on projects ranging from the use of elementary data analysis to the development of large-scale regression models. His current research focuses on the application of total quality management in an academic setting.

Preface

Approximately 25 years ago, the three of us were assistant professors in the Department of Quantitative Analysis at the University of Cincinnati. Our graduate educations and experiences had convinced us of the valuable potential for management science and operations research techniques in business administration and related fields. We were committed to the challenge of writing a textbook that would help make the mathematical and technical concepts of management science understandable and useful to nonmathematicians. Judging from the responses from our teaching colleagues and thousands of students, we have successfully met that challenge. Thus, 25 years later, assisted by the helpful comments and suggestions of many users, we are pleased to offer the eighth edition of *An Introduction to Management Science.*

Our purpose continues to be to provide students with a sound conceptual understanding of the role that management science plays in the decision-making process. Written with the needs of the nonmathematician in mind, the text is applications oriented. As each new concept is introduced, a problem scenario or application is presented to help illustrate the topic; we then explain how management science assists in solving the problem. Using this style throughout the text, we describe the many quantitative methods that have been developed over the years, explain how they work, and show how they can be applied and interpreted. We have found that this approach helps to motivate the student by demonstrating not only how the procedure works, but also how it can contribute to the decision-making process.

Changes in the Eighth Edition

In preparing the eighth edition, we have been careful to maintain the overall format and approach of the previous editions. However, based on our own classroom experience and suggestions from users of previous editions, a number of changes have been made to enhance the content, managerial orientation, and readability of the text.

New Management Science in Practice Applications

End-of-chapter application sections provided by practitioners continue to be a feature of the text. We are pleased to be able to add recent management science applications from Procter & Gamble (Chapter 7) and Citibank (Chapter 12). These applications provide

information about the company, the role of management science within the company, and an overview of a management science application that relates to the material the student has covered in the chapter. A total of 15 management science in practice applications now appear in the text.

Management Science in Action Vignettes

We have added more than 20 Management Science in Action vignettes throughout the text. They provide brief overviews of how the nearby text material has been used successfully in practice. Most are based on articles from *Interfaces*. The intent is to show the student that people actually are using the methods successfully. The vignettes complement the problem scenarios that are an integral part of the text and the chapter-ending applications prepared by practitioners.

Linear and Integer Programming

Chapter 4 has undergone a major revision. Two new applications have been added. One concerns the best mix of government securities for retiring future debt obligations. The other involves a company's decision about how much to produce on regular time and overtime versus how much to buy from outside suppliers. The section on data envelopment analysis has been completely rewritten to improve the pedagogy. Other chapter revisions involve more discussion concerning interpretation of computer output and sensitivity analysis.

Chapter 8 has been revised to show more types of applications of integer linear programming. A new section on fixed charge problems has been added. We show how to model production problems involving a setup cost and a variable cost per unit produced. This new material eases the transition into the plant location and distribution problem. A new case problem involving production scheduling with setup costs has also been added.

Chapter 5 on the simplex method has been shortened, and the branch-and-bound section has been dropped from the chapter on integer linear programming. These changes are in keeping with our increasing emphasis on managerial interpretation and computer solution of problems.

Project Scheduling: PERT/CPM

Chapter 10 has been revised to demonstrate the activity on node network representation of a project scheduling problem. We changed to this approach because the network model is easier to construct (no dummy arcs are necessary) and the crashing model is easier to develop. The changes enhance understanding without any loss of applicability.

Simulation

The chapter on simulation has been completely rewritten and modernized. The chapter begins with an application involving risk analysis and makes extensive use of spreadsheet output. An inventory simulation model and a waiting line simulation model are also covered. The use of spreadsheets has eliminated the dependence on using random number tables and performing simulation computations by hand. A chapter appendix shows how to use Microsoft Excel for simulation.

Spreadsheet Appendixes

Spreadsheet packages, such as Microsoft Excel and Lotus 1-2-3, have rapidly been adding management science solvers to their basic packages. Both Excel and Lotus 1-2-3 have the capability to solve linear programs. We added spreadsheet appendixes to six chapters to show how to use spreadsheets to implement some of the methods explained in the text. Microsoft Excel is used for the demonstrations, but users of other types of spreadsheets should have little difficulty adapting the material. For students and faculty who are comfortable with spreadsheets, these provide an alternative to the software tools provided by management science software packages. Of course, The Management Scientist and LINDO software packages are still described and illustrated in the text.

Other Changes

Many other changes, suggested by users, have been made. A number of student and instructor annotations have also been added and about 15 percent of the problems are new to this edition.

Prerequisite

The mathematical prerequisite for this text is a course in algebra. An introductory knowledge of probability and statistics would be desirable, but not necessary, for Chapters 10–14, 16, and 17.

Throughout the text, we have utilized generally accepted notation for the topic being covered. Thus, students who pursue study beyond the level of this text should find the difficulties of reading more advanced material minimized. To assist in further study, a bibliography is included in Appendix E of the book.

Course Outline Flexibility

The text has been designed to enhance the instructor's flexibility in selecting topics to meet specific course needs. The single-quarter and single-semester outlines that follow are a sampling of the many options available.

A one-quarter outline stressing linear programming, model development, and applications:

- Introduction (Chapter 1)
- Introduction to Linear Programming and Computer Solution (Chapters 2 and 3)
- Linear Programming Applications (selected portions of Chapters 4 and 7)
- Project Management: PERT/CPM (Chapter 10)
- Waiting Lines (Chapter 12)
- Computer Simulation (Chapter 13)
- Decision Analysis (Chapter 14)

The instructor in a one-semester course who wants to focus on model development and other applications could either spend more time on the applications in Chapter 4 or cover additional topics. One possible outline, stressing linear programming, model development, and applications, would be

- Introduction (Chapter 1)
- Introduction to Linear Programming (Chapters 2 and 3)
- Linear Programming Applications (Chapter 4)
- Simplex Method (Chapters 5 and 6)
- Transportation, Assignment, and Transshipment Models (Chapter 7)
- Integer Programming (Chapter 8)
- Project Management: PERT/CPM (Chapter 10)
- Inventory Models (Chapter 11)
- Waiting Lines (Chapter 12)
- Computer Simulation (Chapter 13)
- Decision Analysis (Chapter 14)
- Multicriteria Decision Making (Chapter 15)

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Our associates from organizations who supplied the Management Science in Practice applications made a major contribution to the text. These individuals are cited in a credit line on the first page of each application.

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