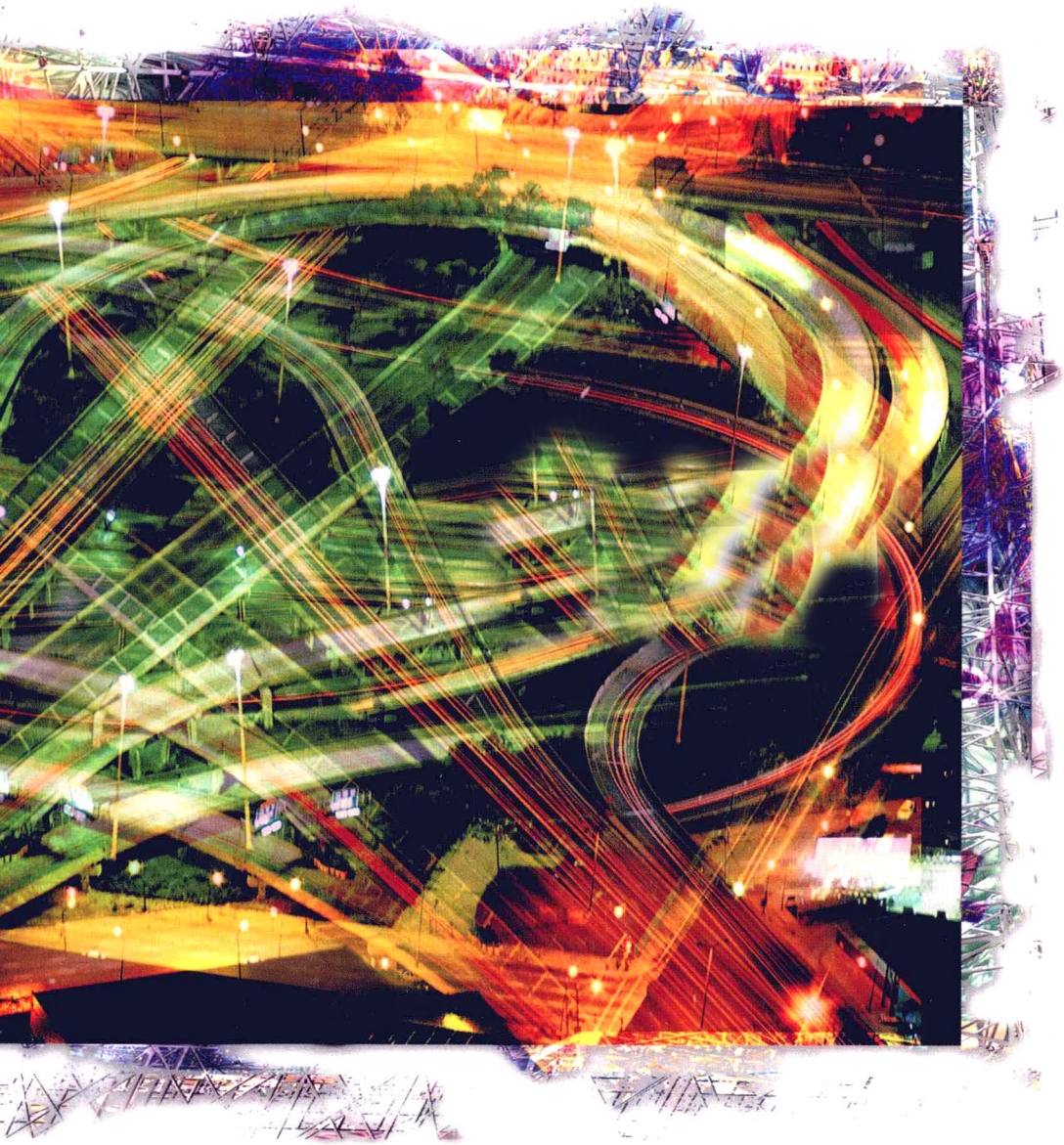
Introduction to Management Science

Eighth Edition



Bernard W. Taylor III

Introduction to Management Science

Eighth Edition

Bernard W. Taylor III

Virginia Polytechnic Institute and State University

Prentice Hall
Upper Saddle River, New Jersey 07458

Library of Congress Cataloging-in-Publication Data

Taylor, Bernard W.
Introduction to management science / Bernard W. Taylor III.— 8th ed.
p. cm.
ISBN 0-13-142439-4 (alk. paper)
1. Management science. I. Title.
T56.T38 2004
658.5--dc22
2003055739

Executive Editor: Tom Tucker
Editor-in-Chief: P.J. Boardman
Project Manager: Erika Rusnak
Editorial Assistant: Dawn Stapleton
Senior Project Manager, Media: Nancy Welcher
Executive Marketing Manager: Debbie Clare
Marketing Assistant: Amanda Fisher
Managing Editor (Production): Cynthia Regan
Production Editor: Denise Culhane
Production Assistant: Joe DeProspero
Permissions Supervisor: Suzanne Grappi
Production Manager: Arnold Vila
Design Manager: Maria Lange
Art Director: Janet Slowik
Interior Designer: Blair Brown/Jill Little
Cover Design: Jill Little
Cover Illustration: Digital Vision, Ltd.
Photo Researcher: Melinda Alexander
Image Permission Coordinator: Nancy Seise
Manager, Print Production: Christy Mahon
Composition/Full-Service Project Management: Ashley Scattergood
Printer/Binder: Courier-Westford

Credits and acknowledgments borrowed from other sources and reproduced, with permission, in this textbook appear on appropriate page within text and on page 763.

Microsoft Excel® and Windows® are registered trademarks of Microsoft Corporation in the U.S.A. and other countries. Screen shots and icons reprinted with permission from the Microsoft Corporation. This book is not sponsored or endorsed by or affiliated with Microsoft Corporation.

Pearson Education LTD.
Pearson Education Singapore, Pte. Ltd
Pearson Education, Canada, Ltd
Pearson Education–Japan
Pearson Education Australia PTY, Limited
Pearson Education North Asia Ltd
Pearson Educación de Mexico, S.A. de C.V.
Pearson Education Malaysia, Pte. Ltd

PEARSON
Prentice
Hall

10 9 8 7 6 5 4 3 2 1
ISBN 0-13-142439-4

To Diane, Kathleen, and Lindsey
To the memory of my grandfather,
Bernard W. Taylor Sr.

Preface

The objective of management science is to solve the decision-making problems that confront and confound managers in both the public and the private sector by developing mathematical models of those problems. These models have traditionally been solved with various mathematical techniques, all of which lend themselves to specific types of problems. Thus, management science as a field of study has always been inherently mathematical in nature, and as a result sometimes complex and rigorous. When I began writing the first edition of this book in 1979, my main goal was to make these mathematical topics seem less complex and thus more palatable to undergraduate business students. To achieve this goal I started out by trying to provide simple, straightforward explanations of often difficult mathematical topics. I tried to use lots of examples that demonstrated in detail the fundamental mathematical steps of the modeling and solution techniques. Although in the last two decades the emphasis in management science has shifted away from strictly mathematical to mostly computer solutions, my objective has not changed. I have provided clear, concise explanations of the techniques used in management science to model problems, and provided lots of examples of how to solve these models on the computer, while still including some of the fundamental mathematics of the techniques.

The stuff of management science can seem abstract, and students sometimes have trouble perceiving the usefulness of quantitative courses in general. I remember when I was a student I could not foresee how I would use such mathematical topics (in addition to a lot of the other things I learned in college) in any job after graduation. Part of the problem is that the examples used in books often do not seem realistic. Unfortunately, examples must be made simple to facilitate the learning process. Larger, more complex examples reflecting actual applications would be too complex to help the student learn the modeling technique. The modeling techniques presented in this text are, in fact, used extensively in the business world and their use is increasing rapidly because of computer and information technology. Therefore, the chances of students using the modeling techniques that they learn from this text in a future job are very great indeed.

Even if these techniques are not used on the job, the logical approach to problem solving embodied in management science is valuable for all types of jobs in all types of organizations. Management science consists of more than just a collection of mathematical modeling techniques; it embodies a philosophy of approaching a problem in a logical manner, as does any science. Thus, this text not only teaches specific techniques but also provides a very useful method for approaching problems.

My primary objective throughout all revisions of this text is readability. The modeling techniques presented in each chapter are explained with straightforward examples that avoid lengthy written explanations. These examples are organized in a logical step-by-step fashion that the student can subsequently apply to the Problems at the end of each chapter. I have tried to avoid complex mathematical notation and formulas wherever possible. These various factors will, I hope, help make the material more interesting and less intimidating to students.

Learning Features

This eighth edition of *Introduction to Management Science* includes many features that are designed to help sustain and accelerate the student's learning of the material. Some of these features remain from the previous editions while others are new to this edition. Several of the strictly mathematical topics—like the simplex and transportation solution methods—are on the accompanying CD-ROM. This frees up text space for additional modeling examples in several of the chapters, allowing more emphasis on computer solutions with Excel spreadsheets, and added additional homework problems. In the following sections, we will summarize these and other learning features that appear in the text.

Text Organization An important objective is to have a well-organized text that flows smoothly and follows a logical progression of topics, placing the different management science modeling techniques in their proper perspective. The first 10 chapters group together those chapters related to mathematical programming that can be solved using Excel spreadsheets, including linear, integer, nonlinear, and goal programming as well as network techniques.

Within these mathematical programming chapters the traditional simplex procedure for solving linear programming problems mathematically is located on the CD-ROM

that accompanies this text. It can still be covered by the student on the computer as part of linear programming or it can be excluded, without leaving a "hole" in the presentation of this topic. The integer programming mathematical branch and bound solution method is also on the CD-ROM. In chapter 6, on the transportation and assignment problems, the strictly mathematical solution approaches, including the northwest corner, VAM, and steppingstone methods, are also on the accompanying CD-ROM. Since transportation and assignment problems are specific types of network problems, the two chapters that cover network flow models and project networks that can be solved with linear programming, as well as traditional model-specific solution techniques and software, follow chapter 6 on transportation and assignment problems. In addition, in chapter 10, on nonlinear programming, the traditional mathematical solution techniques, including the substitution method and the method of Lagrange multipliers, are on the CD-ROM.

Chapters 11 through 14 include topics generally thought of as being probabilistic, including probability and statistics, decision analysis, queuing, and simulation. A module on Markov analysis is on the accompanying CD-ROM. Also, a module on game theory, is on the CD-ROM. Forecasting in chapter 15 and inventory in chapter 16 are both unique topics related to operations management.

New Topics and Sections in This Edition In an effort to keep the book current and abreast of contemporary trends in management science, and especially the increased emphasis on model development and solution with Excel spreadsheets, several chapters have been altered to include new sections. In chapter 1, a section on Decision Support Systems DSS has been added. In chapter 8, on project management, new sections have been added on Gantt Charts, activity-on-node networks, and Microsoft Project.

Excel Spreadsheets This new edition continues to emphasize Excel spreadsheet solutions of problems. Spreadsheet solutions are demonstrated in all the chapters in the text (except for chapter 2, on linear programming modeling and graphical solution), for virtually every management science modeling technique presented. These spreadsheet solutions are presented in optional subsections, allowing the instructor to decide whether to cover them. The text includes over 175 Excel spreadsheet screens, most of which include reference callout boxes that describe the solution steps within the spreadsheet. Files that include all the Excel spreadsheet model solutions for the examples in the text are included on the accompanying CD-ROM, and can be easily downloaded by the student to determine how the spreadsheet was set up and the solution derived, and to use as templates to work homework problems. In addition, appendix B at the end of the text provides a tutorial on how to set up and edit spreadsheets for problem solution.

Free Spreadsheet "Add-Ins" Several spreadsheet add-in packages are provided on the CD-ROM that is packaged with every copy of this text, as follows:

Excel QM For some management science topics, the Excel formulas that are required for solution are lengthy and complex and, thus, are very tedious and time-consuming to type into a spreadsheet. In several of these instances in the book, including chapter 6 on transportation and assignment problems, chapter 12 on decision analysis, chapter 13 on queuing, chapter 15 on forecasting, and chapter 16 on inventory control, a spreadsheet "add-in" called Excel QM is demonstrated. These add-ins provide a generic spreadsheet set-up with easy-to-use dialog boxes and all of the formulas already typed in for specific problem types. Unlike other "black box" software, these add-ins allow users to see the formulas used in each cell. The input, results, and the graphics are easily seen and can be easily changed, making this software ideal for classroom demonstrations and student explorations. This software is provided free on the accompanying CD-ROM.

Premium Solver for Education This is an upgraded version of the standard Solver that comes with Excel.

TreePlan Another spreadsheet add-in program that is demonstrated in the text is *TreePlan*, a program that will set up a generic spreadsheet for the solution of decision-tree problems in chapter 12 on decision analysis. This too is provided free on the accompanying CD-ROM.

Crystal Ball Still another spreadsheet add-in program that is included on the accompanying CD-ROM and demonstrated in the book is *Crystal Ball*. Crystal Ball is demonstrated in chapter 14 on simulation and shows how to perform simulation analysis for certain types of risk analysis and forecasting problems.

OPTIONAL Software Package: QM for Windows is the computer package that many students and instructors will prefer to use with this text. This software is very user-friendly, requiring virtually no preliminary instruction except for the "help" screens that can be accessed directly from the program. It is demonstrated throughout the text in conjunction with virtually every management science modeling technique, except simulation. Thus, for most topics problem solution is demonstrated via both Excel spreadsheets and QM for Windows. Files that include all the QM for Windows solutions for examples in the text are included on the accompanying CD-ROM. QM for Windows can be packaged with this text for a reasonable additional price. To order this software packaged with the text, please use ISBN 0-13- 124121-4.

New Problems and Cases Previous editions of the text always provided a substantial number of homework questions, problems, and cases to offer students practice. This

edition includes over 690 homework problems, 30 of which are new, and 48 end-of-chapter cases, 7 of which are new. In addition, four additional spreadsheet modeling cases are provided on this text's Web page, which can be accessed at http://www.prenhall.com/taylor.

Management Science Applications Boxes These boxes are located in every chapter in the text. They describe how a company, organization, or agency uses the particular management science technique being presented and demonstrated in the chapter to compete in a global environment. There are more than 60 of these boxes 16 of which are new, throughout the text and they encompass a broad range of business and public sector applications, both foreign and domestic.

Marginal Notes Notes are included in the margins that serve the same basic function as notes that students themselves might write in the margin. They highlight certain topics to make it easier for the student to locate them, they summarize topics and important points, and they provide brief definitions of key terms and concepts.

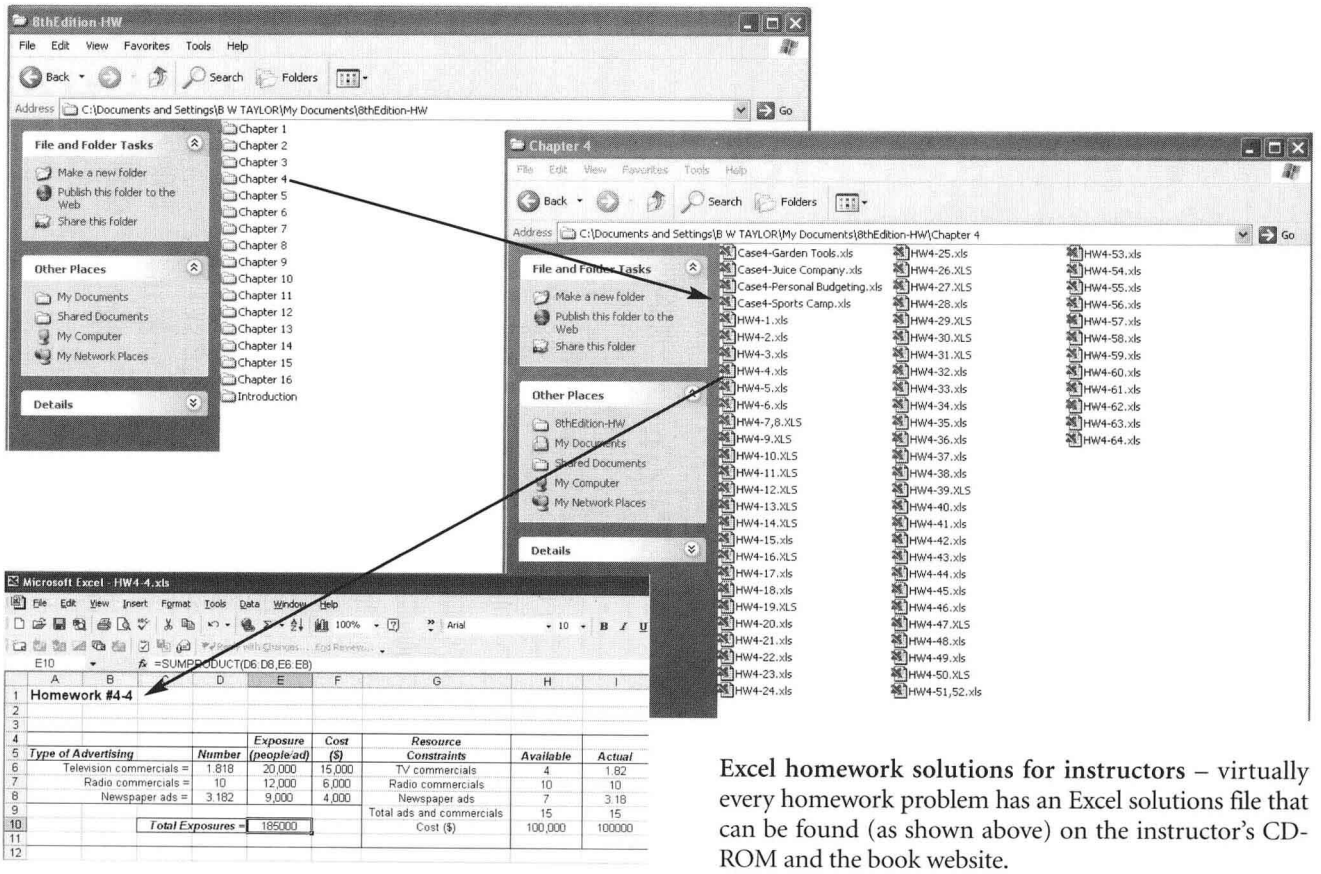
Examples The primary means of teaching the various quantitative modeling techniques presented in this text is through examples. Thus, examples are liberally inserted throughout the text, primarily to demonstrate how problems are solved with the different quantitative techniques and to make them easier to understand. These examples are organized in a logical step-by-step solution approach that the student can subsequently apply to the homework problems.

Solved Example Problems At the end of each chapter, just prior to the homework questions and problems, there is a section with solved examples to serve as a guide for doing the homework problems. These examples are solved in a detailed, step-by-step fashion.

Instructors' and Students' Supplements

For the Instructor:

- Excel Homework Solutions—New to this edition are files for the instructor, which provide computer solutions for all but a few of the end-of-chapter homework and case problems in the text (see illustration below). Most of the computer solutions are Excel spreadsheets. This new edition includes 691 end-of-chapter homework problems and Excel solutions (including those using TreePlan and Crystal Ball) are provided for all



Excel homework solutions for instructors – virtually every homework problem has an Excel solutions file that can be found (as shown above) on the instructor's CD-ROM and the book website.

but 40 of these problems. Excel solutions are also provided for 46 of the 48 end-of-chapter case problems in the text. QM for Windows solutions are provided for all but a few of the remaining homework problems and cases that cannot be easily solved by Excel. Instructors can electronically post these solutions for their students to access or download directly to students' computers. The homework solutions will be available on the Instructor's Resource CD-ROM.

- PowerPoint Presentations—PowerPoint presentations are available for every chapter to enhance lectures. Features figures, tables, Excel work, and main points from the text. Available on the text Web site or on the Instructor's CD-ROM. (0-13-142446-7)
- Instructor's Solutions Manual—the instructor's Solutions Manual contains detailed solutions for all end-of-chapter exercises and cases. In addition to a printed solutions manual, these solutions are provided electronically on the text's Web site and on a separate Instructor's CD-ROM in PDF format. (0-13-142445-9)
- Test Item File—The test item file contains a variety of true/false, multiple choice and problem solving questions for each chapter. (0-13-142440-0)
- Instructor's CD-ROM—this separate CD-ROM (0-13-142445-9), for instructors only, contains the following:

  All of the print supplements listed above, in electronic form.

  Electronic files (with solutions) for almost all of the end-of-chapter exerecises and cases. These files include solutions that use Excel, QM for Windows, Crystal Ball and TreePlan

  All of the files and software programs on the students' CD-ROM

  The TestGen software described below.

- MyCW—this custom website, at www.prenhall.com/taylor contains all of the supplements listed above (Instructor's Solutions Manual, PowerPoint slides, Test Item File) in electronic form and available for download. In addition, Excel, Crystal Ball, TreePlan, QM for Windows* and Microsoft Project 2002* files for many of the examples in the text are on this website. (*QM for Windows and Microsoft Project 2002 are optional packages with this text.)

TestGen Software

The print Test Banks are designed for use with the TestGen test generating software. This computerized package allows instructors to custom design, save, and generate classroom tests. The test program permits instructors to edit, add, or delete questions from the test banks; edit existing graphics and create new graphics; analyze test results; and organize a database of tests and student results. This new software allows for greater flexibility and ease of use. It provides many options for organizing and displaying tests, along with a search and sort feature. (0-13-142441-6)

For the Student:

- FREE CD-ROM—A CD-ROM is packaged with every copy of this book. This CD-ROM contains the following software packages: Premium Solver for Education, Crystal Ball Professional 2000 (v2000.2) Textbook/Student Edition, TreePlan and Excel QM. Also on the CD-ROM are Excel, Crystal Ball, TreePlan, QM for Windows, and Microsoft Project 2002 files for the examples in the text.

Acknowledgments

As with any large project, the revision of a textbook is not accomplished without the help of many people. The eighth edition of this book is no exception, and I would like to take this opportunity to thank those who have contributed to its preparation. First, I would like to thank my friend and colleague, Larry Moore, for his help in developing the organization and approach of the original edition of this book and for his many suggestions during its revisions. We spent many hours discussing what an introductory text in management science should contain, and his ideas appear in these pages. Larry also served as a sounding board for many ideas regarding content, design, and preparation, and he read and edited many portions of the text, for which I am very grateful. I also thank the reviewers of this edition:

I remain indebted to the reviewers of the previous editions: Nagraj Balakrishnan, Edward M. Barrow, Ali Behnezhad, Weldon J. Bowling, Rod Carlson, Petros Christofi, Yar M. Ebadi, Richard Ehrhardt, Warren W. Fisher, James Flynn, Wade Furgeson, Soumen Ghosh, James C. Goodwin Jr., Richard Gunther, Ann Hughes, Shivaji Khade, Shao-ju Lee, Robert L. Ludke, Peter A. Lyew, Robert D. Lynch, Dinesh Manocha, Mildred Massey, Abdel-Aziz Mohamed, Thomas J. Nolan, Susan W. Palocsay, David W. Pentico, Cindy Randall, Roger Schoenfeldt, Charles H. Smith, Lisa Sokol, John Wang, and Barry Wray.

I am also very grateful to Tracy McCoy at Virginia Tech for her typing and editorial assistance. I would like to thank my production editor, Denise Culhane at Prentice Hall for her valuable assistance and patience. Finally, I would like to thank my editor, Tom Tucker at Prentice Hall for his continual help, patience, and prodding.

Brief Contents

Contents

1 Management Science

The Management Science Approach to Problem Solving

Observation • Definition of the Problem • Model Construction • Model Solution • Implementation

TIME OUT for Pioneers in Management Science

Management Science Application: Management Science at Taco Bell

Model Building: Break-Even Analysis

Components of Break-Even Analysis • Computing the Break-Even Point • Graphical Solution • Sensitivity Analysis

Computer Solution

Excel Spreadsheets • The Excel QM Macro for Spreadsheets • QM for Windows

Management Science Modeling Techniques

Linear Mathematical Programming Techniques • Probabilistic Techniques • Network Techniques • Other Techniques

Management Science Application: Management Science at Federal Express

Business Usage of Management Science Techniques

Management Science Models in Decision Support Systems

Management Science Application: A Decision Support System for Aluminum Can Production at Coors

Summary · References · Problems · Case Problems