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Anderson
Sweeney
Williams
Camm
Martin

# An Introduction to Management Science

## Quantitative Approaches to Decision Making

REVISED THIRTEENTH EDITION

# AN INTRODUCTION TO MANAGEMENT SCIENCE

## QUANTITATIVE APPROACHES TO DECISION MAKING


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**An Introduction to Management Science: Quantitative Approaches to Decision Making, Revised Thirteenth Edition**
**David R. Anderson, Dennis J. Sweeney, Thomas A. Williams, Jeffrey D. Camm, & Kipp Martin**

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MPS Limited, a Macmillan Company

Senior Art Director:
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Internal Designer:
Michael Stratton/Chris Miller Design

Cover Designer:
Craig Ramsdell

Cover Images:
© Getty Images/GlowImages



Library of Congress Control Number: 2010935955

Student Edition ISBN 13: 978-1-111-53224-6
Student Edition ISBN 10: 1-111-53224-9
Package Student Edition ISBN 13: 978-1-111-53222-2
Package Student Edition ISBN 10: 1-111-53222-2

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Printed in the United States of America
1 2 3 4 5 6 7 14 13 12 11

REVISED THIRTEENTH EDITION

# AN INTRODUCTION TO MANAGEMENT SCIENCE

## QUANTITATIVE APPROACHES TO DECISION MAKING

*Dedication*

*To My Parents*
*Ray and Ilene Anderson*
*DRA*

*To My Parents*
*James and Gladys Sweeney*
*DJS*

*To My Parents*
*Phil and Ann Williams*
*TAW*

*To My Wife*
*Karen Camm*
*JDC*

*To My Wife*
*Gail Honda*
*KM*

# Preface

We are very excited to publish the revised thirteenth edition of a text that has been a leader in the field for over 20 years. The purpose of this revised thirteenth edition, as with previous editions, is to provide undergraduate and graduate students with a sound conceptual understanding of the role that management science plays in the decision-making process. The text describes many of the applications where management science is used successfully. Former users of this text have told us that the applications we describe have led them to find new ways to use management science in their organizations.

*An Introduction to Management Science* is applications oriented and continues to use the problem-scenario approach that is a hallmark of every edition of the text. Using the problem-scenario approach, we describe a problem in conjunction with the management science model being introduced. The model is then solved to generate a solution and recommendation to management. We have found that this approach helps to motivate the student by not only demonstrating how the procedure works, but also how it contributes to the decision-making process.

From the very first edition we have been committed to the challenge of writing a textbook that would help make the mathematical and technical concepts of management science understandable and useful to students of business and economics. Judging from the responses from our teaching colleagues and thousands of students, we have successfully met the challenge. Indeed, it is the helpful comments and suggestions of many loyal users that have been a major reason why the text is so successful.

Throughout the text we have utilized generally accepted notation for the topic being covered so those students who pursue study beyond the level of this text should be comfortable reading more advanced material. To assist in further study, a references and bibliography section is included at the back of the book.

## CHANGES IN THE REVISED THIRTEENTH EDITION

The thirteenth edition of *Management Science* is a major revision. We are very excited about it and want to tell you about some of the changes we have made and why.

In addition to the major revisions described in the remainder of this section, this *revised* edition of the thirteenth edition has been updated to incorporate Microsoft® Office Excel® 2010. This involves some changes in the user interface of Excel and major changes in the interface and functionality of Excel Solver. The Solver in Excel 2010 is more reliable than in previous editions and offers new alternatives such as a multistart option for difficult nonlinear problems.

### New Member of the ASWM Team

Prior to getting into the content changes, we want to announce that we are adding a new member to the ASWM author team. His name is Jeffrey Camm. Jeff received his Ph.D. from Clemson University. He has been at the University of Cincinnati since 1984, and has been a visiting scholar at Stanford University and a visiting professor of business administration at the Tuck School of Business at Dartmouth College. Jeff has published over 30 papers in the general area of optimization applied to problems in operations management. At the University of Cincinnati, he was named the Dornoff Fellow of Teaching Excellence and

he was the 2006 recipient of the INFORMS Prize for the Teaching of Operations Research Practice. He currently serves as editor-in-chief of *Interfaces,* and is on the editorial board of *INFORMS Transactions on Education.* We welcome Jeff to the new ASWCM team and expect the new ideas from Jeff will make the text even better in the years to come.

In preparing this thirteenth edition, we have been careful to maintain the overall format and approach of the previous edition. However, based on our classroom experiences and suggestions from users of previous editions, a number of changes have been made to enhance the text.

## Made the Book Less Reliant on Specific Software

The first eight chapters on optimization no longer use output from The Management Scientist software. All figures illustrating computer output are generic and are totally independent of software selection. This provides flexibility for the instructor. In addition, we provide appendices that describe how to use Excel Solver and LINGO. For every model illustrated in the text we have both Excel and LINGO files available at the website. Prior users of The Management Scientist wishing to upgrade to similar software should consider using LINGO. This will be an easy transition and LINGO is far more flexible than The Management Scientist. The documented LINGO models (not available in MS 12e), available at the website, will aide in the transition. Excel Solver and LINGO have an advantage over The Management Scientist in that they do not require the user to move all variables to the left-hand side of the constraint. This eliminates the need to algebraically manipulate the model and allows the student to enter the model in the computer in its more natural form. For users wishing to use The Management Scientist, it will continue to be available on the website for the text.

## New Appendix A: Building Spreadsheet Models

This appendix will prove useful to professors and students wishing to solve optimization models with Excel Solver. The appendix also contains a section on the principles of good spreadsheet modeling and a section on auditing tips. Exercises are also provided.

## Chapter 15 Thoroughly Revised

Chapter 15, Times Series Analysis and Forecasting, has been thoroughly revised. The revised chapter is more focused on time series data and methods. A new section on forecast accuracy has been added and there is more emphasis on curve fitting. A new section on nonlinear trend has been added. In order to better integrate this chapter with the text, we show how finding the best parameter values in forecasting models is an application of optimization, and illustrate with Excel Solver and LINGO.

## New Project Management Software

In Chapter 9, Project Scheduling: PERT/CPM, we added an appendix on Microsoft Office Project. This popular software is a valuable aid for project management and is software that the student may well encounter on the job. This software is available on the CD that is packaged with every new copy of the text.

## Chapter 3 Significantly Revised

We significantly revised Chapter 3, Linear Programming: Sensitivity Analysis and Interpretation of Solution. The material is now presented in a more up-to-date fashion and emphasizes the ease of using software to analyze optimization models.

### New Management Science in Action, Cases, and Problems

Management Science in Action is the name of the short summaries that describe how the material covered in a chapter has been used in practice. In this edition you will find numerous Management Science in Action vignettes, cases, and homework problems.

### Other Content Changes

A variety of other changes, too numerous to mention individually, have been made throughout the text in responses to suggestions of users and our students.

## COMPUTER SOFTWARE INTEGRATION

We have been careful to write the text so that it is not dependent on any particular software package. But, we have included materials that facilitate using our text with several of the more popular software packages. The following software and files are available on the website for the text:

- LINGO trial version,
- LINGO and Excel Solver models for every optimization model presented in the text,
- Microsoft® Excel worksheets for most of the examples used throughout the text,
- TreePlan™ Excel add-in for decision analysis and manual.

Microsoft Project is provided on the CD that is packaged with every new copy of the text.

## FEATURES AND PEDAGOGY

We have continued many of the features that appeared in previous editions. Some of the important ones are noted here.

### Annotations

Annotations that highlight key points and provide additional insights for the student are a continuing feature of this edition. These annotations, which appear in the margins, are designed to provide emphasis and enhance understanding of the terms and concepts being presented in the text.

### Notes and Comments

At the end of many sections, we provide Notes and Comments designed to give the student additional insights about the statistical methodology and its application. Notes and Comments include warnings about or limitations of the methodology, recommendations for application, brief descriptions of additional technical considerations, and other matters.

### Self-Test Exercises

Certain exercises are identified as self-test exercises. Completely worked-out solutions for those exercises are provided in an appendix at the end of the text. Students can attempt the self-test exercises and immediately check the solution to evaluate their understanding of the concepts presented in the chapter.

## ACKNOWLEDGMENTS

We owe a debt to many of our academic colleagues and friends for their helpful comments and suggestions during the development of this and previous editions. Our associates from organizations who supplied several of the Management Science in Action vignettes make a major contribution to the text. These individuals are cited in a credit line associated with each vignette.

We are also indebted to our senior acquisitions editor, Charles McCormick, Jr.; our marketing communications manager, Libby Shipp; our developmental editor, Maggie Kubale; our content project manager, Jacquelyn K Featherly; our media editor, Chris Valentine; and others at Cengage Business and Economics for their counsel and support during the preparation of this text. We also wish to thank Lynn Lustberg, Project Manager at MPS Content Services for her help in manuscript preparation.

*David R. Anderson*
*Dennis J. Sweeney*
*Thomas A. Williams*
*Jeffrey D. Camm*
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# About the Authors

**David R. Anderson.** David R. Anderson is Professor Emeritus of Quantitative Analysis in the College of Business Administration at the University of Cincinnati. Born in Grand Forks, North Dakota, he earned his B.S., M.S., and Ph.D. degrees from Purdue University. Professor Anderson has served as Head of the Department of Quantitative Analysis and Operations Management and as Associate Dean of the College of Business Administration. In addition, he was the coordinator of the College's first Executive Program.

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 ten 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 Emeritus of Quantitative Analysis and Founder of the Center for Productivity Improvement at the University of Cincinnati. Born in Des Moines, Iowa, he earned a B.S.B.A. degree from Drake University and his M.B.A. and D.B.A. degrees from Indiana University, where he was an NDEA Fellow. During 1978–79, Professor Sweeney worked in the management science group at Procter & Gamble; during 1981–82, he was a visiting professor at Duke University. Professor Sweeney served as Head of the Department of Quantitative Analysis and as Associate Dean of the College of Business Administration at the University of Cincinnati.

Professor Sweeney has published more than thirty articles and monographs in the area of management science and statistics. The National Science Foundation, IBM, Procter & Gamble, Federated Department Stores, Kroger, 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 ten textbooks in the areas of statistics, management science, linear programming, and production and operations management.

**Thomas A. Williams.** Thomas A. Williams is Professor Emeritus of Management Science 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 seven 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 graduate courses in regression and decision analysis.

Professor Williams is the coauthor of eleven 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 data analysis to the development of large-scale regression models.

**Jeffrey D. Camm.** Jeffrey D. Camm is Professor of Quantitative Analysis and Head of the Department of Quantitative Analysis and Operations Management at the University of Cincinnati. Dr. Camm earned a Ph.D. in management science from Clemson University and a B.S. in mathematics from Xavier University. He has been at the University of Cincinnati since 1984, has been a visiting scholar at Stanford University, and a visiting professor of business administration at the Tuck School of Business at Dartmouth College. Dr. Camm has published over 30 papers in the general area of optimization applied to problems in operations management and his research has been funded by the Air Force Office of Scientific Research, the Office of Naval Research, and the U.S. Department of Energy. He was named the Dornoff Fellow of Teaching Excellence by the University of Cincinnati College of Business and he was the 2006 recipient of the INFORMS Prize for the Teaching of Operations Research Practice. He currently serves as editor-in-chief of *Interfaces,* and is on the editorial board of *INFORMS Transactions on Education.*

**Kipp Martin.** Kipp Martin is Professor of Operations Research and Computing Technology at the Booth School of Business, University of Chicago. Born in St. Bernard, Ohio, he earned a B.A. in mathematics, an MBA, and a Ph.D. in management science from the University of Cincinnati. While at the University of Chicago, Professor Martin has taught courses in management science, operations management, business mathematics, and information systems.

Research interests include incorporating Web technologies such as XML, XSLT, XQuery, and Web Services into the mathematical modeling process; the theory of how to construct good mixed integer linear programming models; symbolic optimization; polyhedral combinatorics; methods for large scale optimization; bundle pricing models; computing technology; and database theory. Professor Martin has published in *INFORMS Journal of Computing, Management Science, Mathematical Programming, Operations Research, The Journal of Accounting Research,* and other professional journals. He is also the author of *The Essential Guide to Internet Business Technology* (with Gail Honda) and *Large Scale Linear and Integer Optimization.*

# Brief Contents

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