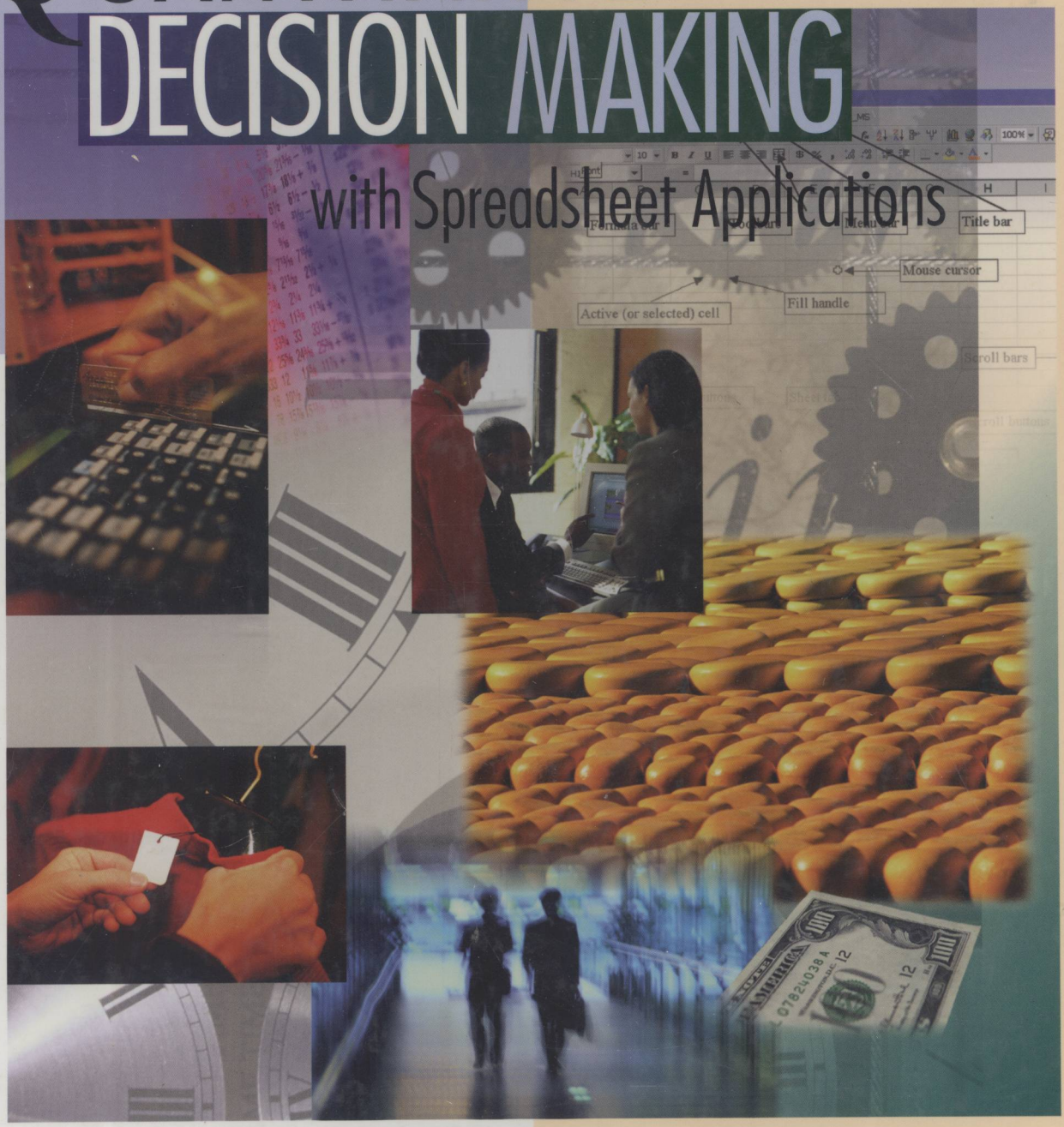
QUANTITATIVE DECISION MAKING

7TH EDITION

with Spreadsheet Applications



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QUANTITATIVE DECISION MAKING

7TH EDITION

with Spreadsheet Applications

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To Lía, Max, and Charlotte

Es intentando lo imposible como se realiza lo posible.

PREFACE

Our goal in writing *Quantitative Decision Making with Spreadsheet Applications* has been to provide a complete and modern treatment of basic management science methodology. The book is written for college students who have only a limited algebra background. Even more important, it is designed to provide them with a feeling for the variety and power of management science tools, to alleviate their apprehension of the subject, and to enable them to recognize on-the-job situations in which management science methodology can be successfully employed.

Although this is the seventh edition, it is in many ways a new book, due largely to the inclusion of spreadsheet applications. The book's primary software tool is now Microsoft Excel and the add-ins Precision Tree, *@RISK*, BestFit, and RISKView. Those software programs are complemented by the upgraded *QuickQuant 2000* for Windows, which now covers what is not easy to do with Excel or its family of add-ons. All needed software is provided on the CD-ROM that accompanies new copies of this book at no added cost to students.

Although this book embraces several commercial software packages, it keeps the original look and feel. Small problems are still meant to be worked out by hand, and explanations of the underlying models have not been sacrificed to make room for the new. All of the essentials for a first course in quantitative methods are still here, and there is still plenty of choice regarding course topics.

This seventh edition provides a streamlined topical sequence that minimizes jumping back and forth. Its six parts will make it easier for readers to navigate (see the Contents page for a complete listing). The many improvements were motivated by a desire to improve the book's effectiveness while reducing hand computational demands and giving better explanations in those areas where our own students had difficulties. Text revisions appearing in this seventh edition are the most extensive ever in accordance with the dual objectives of making better use of the computer and showing students the relevance of management science to everyday business decision making.

IMPORTANT FEATURES OF THE SEVENTH EDITION

This revision has undergone a complete overhaul, including three drafts, the efforts of many hundreds of students, and countless nights and weekends to get it just right. To this end, the seventh edition of *Quantitative Decision Making* has adopted five major themes to make it modern, practical, and pedagogically effective.

Relevancy

First, we wanted to make the material come alive for students and address their misconception that management science is not relevant. Students must recognize that quantitative concepts and decision-making ability are life skills that will help them immeasurably in their future endeavors. Specifically, we offer the following enhancements:

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- The *expanded introduction* substantially broadens exposure to real-life applications.
- *Practical spreadsheet applications appear throughout.* In today's computerized environment, the optimal focus in teaching quantitative methods emphasizes concepts more than hand computations with algorithms, so each chapter contains computer applications that are integrated throughout nearly every chapter, not just at the end of each chapter. The effect of this integration is the inclusion of more realistic illustrations that reflect the types of problems students will face in their future studies and careers.

Concepts Presented with a Student Orientation

In this way, our second theme recognizes that today's students acquire quantitative skills in different ways. We have been careful to fully develop important concepts, often breaking them down into manageable chunks. Specifically:

- *Optimization concepts are reorganized to offer maximum flexibility in course coverage.* Linear programming and its extensions are covered in a more streamlined way. This has been partly achieved by placing the simplex method in an optional section. Those students who seek the simplex details will still be able to find them.
- *Improved topical groupings and simpler presentations are provided.* The linear programming group also has been simplified by combining duality, sensitivity, and postoptimality analysis in a single chapter that emphasizes using the computer and linear programming to strategically improve the business environment. In that same vein, integer and goal programming are combined in one chapter, and transportation problems appear together with assignment problems.
- *Although large problems need computer solutions, small problems are always first solved by hand.* Every topic is explained with concepts, the underlying model, and the solution algorithm. Small problems are used for this—always to be solved first by hand. After those preliminaries, computer tools are described. We strongly believe that skill in using software is just one element to learning quantitative methods.
- *Easy-to-apply algorithms are featured and richly illustrated.* For instance, the complete transportation method is described in such a way that students can work small problems by hand and acquire the flavor of a user-friendly multistep algorithm. They can check themselves with *QuickQuant 2000,* which shows all details as an option, and most will find that package easier than Excel for solving these problem types.

Greater Focus on Decision Analysis

Our third theme was places greater emphasis on this main purpose for studying quantitative methods. To that end, this book:

- *More strongly emphasizes decision making.* The second chapter on probability (Chapter 4) discusses distributions. Its new sections on subjective probability are positioned earlier to reflect its expanding role in decision making.
- *Places decision analysis earlier.* Moving decision analysis up to Chapters 5 and 6 further emphasizes the importance of decision making. The earlier placement of

certainty equivalents, risk premiums, and utility acknowledges of the growing relevance of those topics.

Computing and Spreadsheets

Our fourth theme reflects the latest practice in applying quantitative methods. We have therefore fully embraced spreadsheet modeling techniques and software.

- The new Chapter 2 introduces electronic spreadsheets and Excel. (It may be skipped by students who are already familiar with spreadsheets.)
- Excel add-ins are featured wherever they do a superior job. That is especially true of Monte Carlo simulation, which is applied using *@RISK*.
- *QuickQuant 2000* shows all of the steps taken in reaching a solution, eliminating the need to do messy computations by hand. It can display all iterations of simplex, allowing students to see how linear programming actually works. Those optional details are completely hidden by the Excel Solver, which gives answers only.
- Understanding Excel Solver solutions is easily achieved with *QuickQuant 2000.* Since it will exchange data files with Excel, *QuickQuant* can give detailed evaluations for the same linear programs originally solved with a spreadsheet.
- Software illustrations emphasize ease of use and feature the better approaches. For instance, *QuickQuant 2000* has compelling advantages in applying Program management with PERT/CPM, and it is the featured software for that topic. The package constructs the network on screen using only data about the predecessor activities. Although it can exchange files with Excel, the more capable *QuickQuant* can help perform time–cost tradeoffs and Monte Carlo simulations.

Being Current

Finally, our fifth theme is to have this book be up-to-date. We have tried to make it appealing to today's student in many ways. In addition to the spreadsheets, relevant applications, and careful development, we have taken great care to include new problems and cases that are representative of problems that students may face in the workplace.

- Chapters have minicases and motivating quotes. Each chapter begins with words of wisdom and a realistic business problem that is later solved using the concepts just presented.
- Expanded end-of-chapter cases include more applications and utilize the new software tools.
- The chapters and organized problems have been thoroughly tested in class. This book has been used many times in a variety of courses, which has resulted in the culling, revising, and grading of the problem material. In general, the problems are broken into several distinct parts to make the student's job easier and to permit the instructor added flexibility in making assignments. As an added bonus, brief answers to selected problems are provided in the back of the book so that students can check their own work. They may find detailed answers to those problems in the student solutions manual. Questions for each end-of-chapter case appear with the case, and the cases themselves have been upgraded for this edition.
- Hundreds of new problems, improved cases, and larger data sets have been added. The revised book has a new problem mix that can be tailored to students' capabil-

ities. The problems now reflect greater realism and better represent the various techniques and their nuances. To that end, this edition has new cases based on real applications and involving bigger data sets. The problems and cases make even greater use of the computer, allowing considerable potential for course enrichment.

OUR APPROACH

Quantitative Decision Making seeks to develop students' intuition and their ability to apply quantitative techniques to real business problems. Discussions devoted to difficult topics therefore may be longer than those of other books. We believe our explanations, richly illustrated with relevant and interesting examples, will provide more meaningful and easier learning experiences. The book also highlights the limitations and pitfalls associated with various mathematical models and algorithms. For example, some basic models, such as the EOQ model used in inventory decisions and the simple queuing formulas, are based on assumptions that rarely apply in real life. Wherever practical, alternative approaches such as Monte Carlo simulation are indicated and fully described.

ANCILLARY MATERIALS

The Instructor's Suite for Microsoft Office CD-ROM provides teaching suggestions and detailed solutions to the nearly 800 problems and 37 end-of-chapter cases in the text. It includes test items for each chapter and slides in formats that are compatible with Microsoft Office's PowerPoint application.

The test bank on the Instructor's Suite contains a set of approximately 200 solved problems of slight to moderate difficulty.

A comprehensive bibliography is included in the back of the book for students who wish to pursue a particular topic in greater detail.

The Student CD-ROM will contain data files for the problems and Excel templates.

A Student's Solutions Manual is available for student purchase and includes detailed solution to the answers appearing in the back of the book.

Software. The student's and instructor's CD-ROMs both contain the featured software:

- Palisade's DecisionTools (including Precision Tree, BestFit, *@RISK*, and RISKView)
- *QuickQuant 2000 for Windows*
- The above are included with every new copy of the text.
- Software guides for Excel and *QuickQuant 2000* are provided on the student and instructors CD-ROMs.
- A Web site—www.duxbury.com—will provide helpful suggestions for instructors and students who use this book.

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LAWRENCE L. LAPIN
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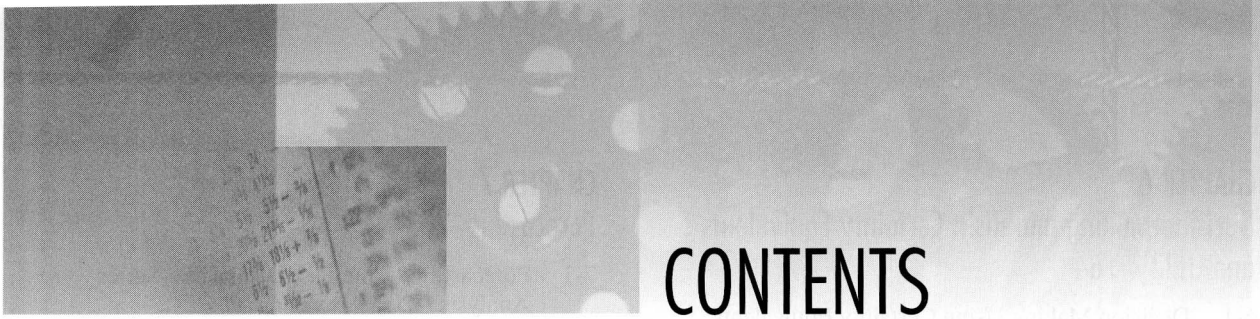

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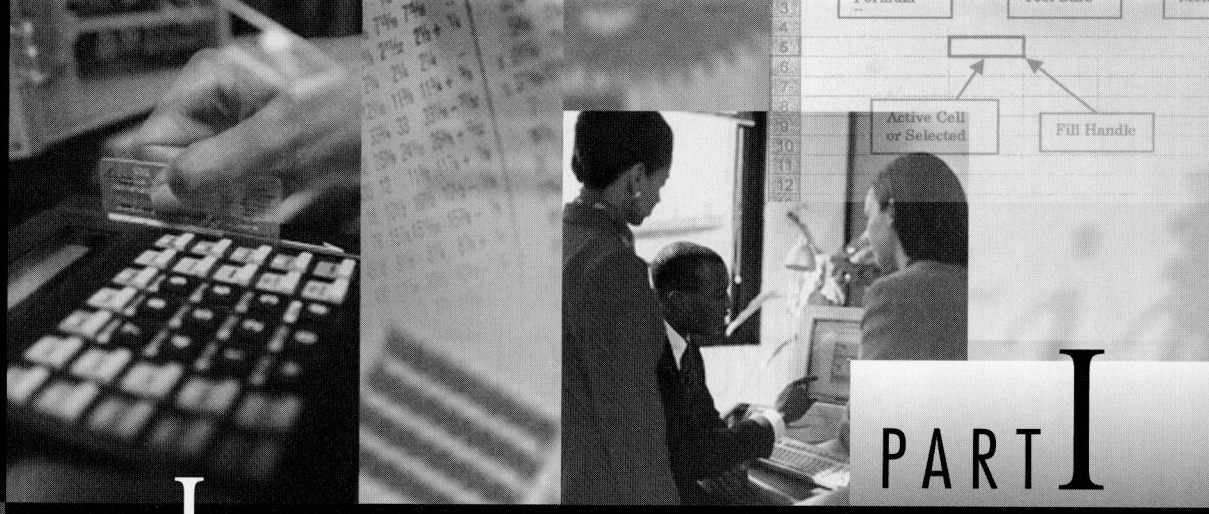

PART I

INTRODUCTION

Every journey begins with the first step.

Widespread utilization of quantitative methods in business has caused a decision-making revolution. According to James Crowe, CEO of Level 3 Communications, they give us "a weapon so powerful that it can help transform even fledgling companies into highly efficient optimized organizations capable of competing on any business battle ground in the world."[1]

Chapter 1 uses illustrations involving actual applications to introduce quantitative methods used by modern businesses.

A second revolution over the past decade has been the widespread use of spreadsheets. Chapter 2 introduces the basic spreadsheet concepts to be developed in this book.

---

[1] James Crowe, quoted in "Something to Crowe About," by Peter Horner, *OR/MS Today* (June 2000), p. 38.

CHAPTER 1

INTRODUCTION TO QUANTITATIVE METHODS

Exposure to quantitative methods will teach managers to ask the right questions.

A quiet revolution has taken place in managerial decision making over the past three decades—a revolution that is due largely to the successful implementation of **quantitative methods** and the widespread use of computers. The list of business problems that these procedures can be employed to solve grows daily, and examples of successful applications can be found in every functional area—from marketing to production, from finance to personnel—and in all major industries. Indeed, quantitative methods can be applied to decision making in general and can be used by individuals or groups, in education, in the professions, and in every type of organization, including governments and nonprofit foundations.

Unfortunately, quantitative methods make up one of the least recognized disciplines. Unlike chemistry or history, the term conjures up no images for most people. This is paradoxical, because quantitative methods touch everybody. This may be because their products are less tangible and deal with systems or services so common that we take them for granted. They are in that sense like bridges and roads—part of our society's infrastructure. Usually we do not think much about them, but we expect them always to be there.

A few examples may help us recognize the ubiquitous, although transparent, nature of quantitative methods. When you break your car's plastic light cover or when your television malfunctions, you can order the necessary replacement part. If the item is out of stock, you can expect to get it soon. That is made possible by the infrastructure for controlling inventories, for which quantitative methods play a pivotal role in the necessary planning. Inventory control is discussed in Chapters 15 and 16.

When you place a telephone call, you expect to hear an instantaneous dial tone and your call to be completed. But in some countries, dial tones can take hours to happen, or circuits are so full that calls cannot be completed. Certainly, engineers have a role in telephone system hardware, but so do quantitative methods, even if their role is unrecognized. Telephone capacity planning is done with two main branches of quantitative methods: queuing analysis (waiting lines) and simulation. These are discussed in Chapters 17 and 18.

Who would ever think of quantitative methods while waiting for a ride at Disneyland? Have you ever wondered why some banks, post offices, or fast-food restaurants have switched from having many lines to one line? Over the last twenty years, big im-

provements in waiting in lines have resulted from applying those same quantitative methods.

In the more developed countries, a letter or package only takes a few days to reach its destination, although you may not be aware of the role played by quantitative methods in developing the delivery systems. In some countries, less fortunate people can never be sure the item will arrive; their countries do not have delivery systems optimized by quantitative methods. Such distribution problems are discussed in Chapter 12.

When you book an airline flight, you do not think of using quantitative methods. Yet today's airline industry would not exist without those tools. They are basic to the computerized airline reservation systems we take for granted. Quantitative methods are also vital in setting ticket prices, scheduling flights, maintaining aircraft, and organizing baggage-handling systems. The procedure common to all those areas is linear programming, discussed in Chapters 8–13.

Quantitative methods are all around us and affect our activities in many ways. Even Nobel Prizes have been awarded for work in this field.[2] It is important to know quantitative methods and how they can be used in our daily lives. The list of their improvements to our well-being gets longer each day. The next section gives some concrete examples.

1-1 CONTINUING STORIES OF SUCCESS WITH QUANTITATIVE METHODS

A few short case histories will demonstrate how useful quantitative methods have been in solving a variety of actual problems.

- **Managing Research and Development** In the late 1950s, the U.S. Navy was faced with the monumental task of equipping its nuclear submarine fleet with Polaris ballistic missiles. A quantitative method called PERT (Program Evaluation and Review Technique) was used to establish schedules and to coordinate and control the efforts of hundreds of contractors.
- **Determining the Number of Bank Tellers** Banks often use quantitative analysis to decide how many tellers are needed at various times during the week, so employee workloads can be balanced and so customers spend a tolerable amount of time waiting in line.
- **Locating Warehouses** A chemical company that produces fertilizers and pesticides employed quantitative methods to determine where to locate its warehouses. The resulting sites minimized the combined annual cost of transportation, storage, and handling.
- **Designing an Oil-Tanker Port Facility** An international oil company committed several hundred million dollars to the construction of a port facility in the Persian Gulf to service oil tankers. Alternative designs were constructed and run "on paper" for a number of years to determine a statistical pattern for future profits. Through this computer simulation, the design was selected that provided the greatest rate of return on invested capital at an acceptable level of risk.

[2] T. C. Koopmans and L. V. Kantorovich split the 1975 Nobel Prize for economics. They did pioneering work in one of the earliest quantitative methods techniques, linear programming. H. Markowitz, the winner of the 1992 prize, did much of the original work in quadratic programming and simulation. J. C. Harsanyi, J. F. Nash, and R. Selten shared the 1994 prize for their original work in game theory.

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