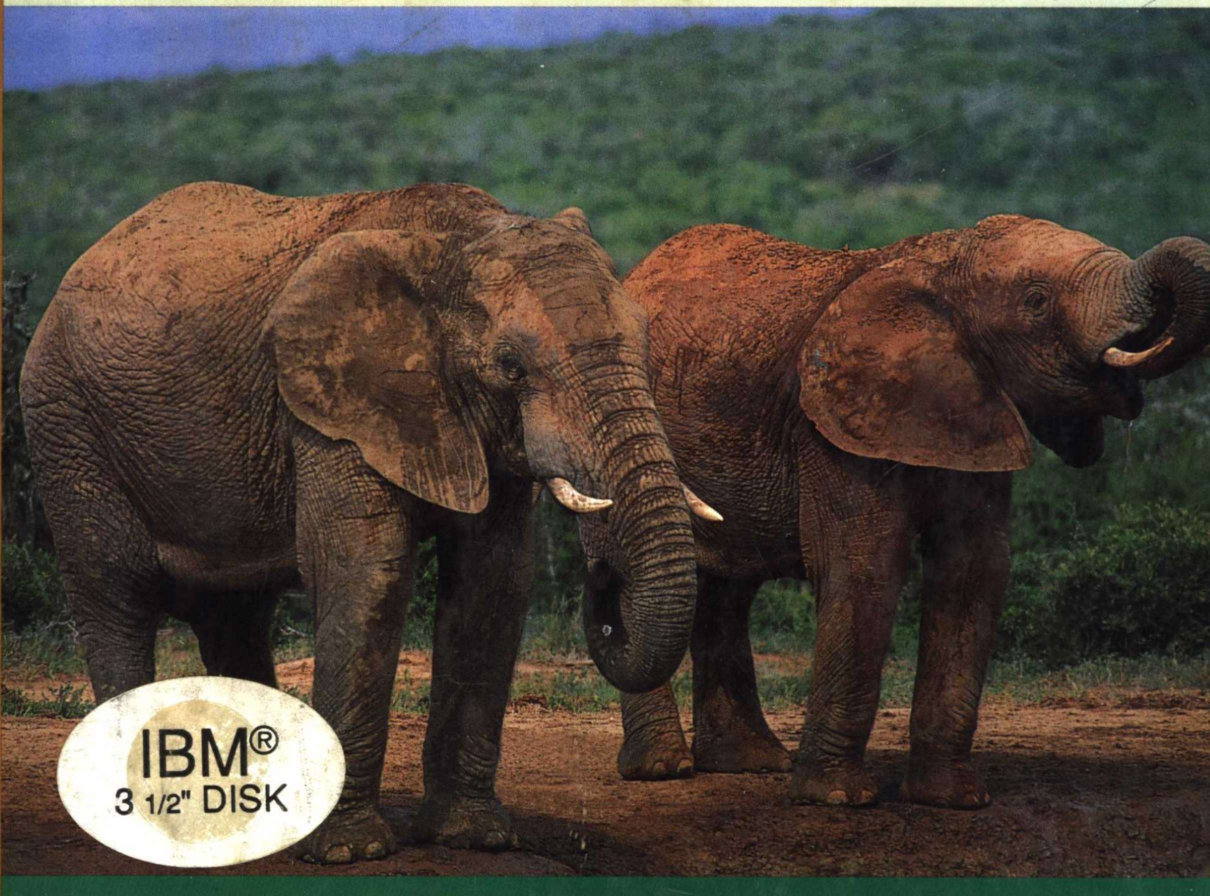
Management Science

A Spreadsheet Approach



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Crummer Graduate School
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▲ *The Scientific Press Series*
boyd & fraser publishing company

Dedication

This book is dedicated to the glory of God.
It is my way of saying "Thanks, God, for the gift of so many blessings."

MANAGEMENT SCIENCE: A SPREADSHEET APPROACH
by Donald R. Plane

▲ *The Scientific Press Series*

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PREFACE

Spreadsheets are widely used in making business decisions. This quantitative language, which managers use more widely than they use algebraic notation, is a very effective language for telling students and managers about management science modeling and solutions. This text assumes that readers have some familiarity with spreadsheets, and have a beginner's ability to use a spreadsheet for managerial purposes. Experience has shown that this spreadsheet approach to teaching management science accomplishes two purposes:

- Students learn management science in a spreadsheet language they will continue to use throughout their careers, and
- Students improve their proficiency with spreadsheets.

The idea of a model is at the heart of management science analysis. The author's experience is that optimization modeling using spreadsheets is an excellent way to practice and improve modeling skills. This modeling method is also useful in many management science techniques, from optimization to decision analysis, risk analysis, inventory models, and waiting line simulation. Each of these topics is included in this text.

This text uses DOS-based spreadsheets, Lotus 1-2-3 Release 2.x and Quattro Pro Version 4, which are widely used by business students. The optimization modeling in Chapters 2 through 12 uses the What's*Best!* solver software that accompanies this text. What's*Best!* uses spreadsheet models to find optimal solutions to linear, nonlinear, and mixed integer programming problems. The models are documented in a way that lets the reader understand and implement the *logic* on any spreadsheet, including spreadsheets with built-in solvers. Appendix C discusses the use of the solvers that are a part of Quattro Pro for DOS or Windows and Excel for windows. The final four chapters of the text deal with uncertainty. The Monte Carlo techniques used in these chapters use the data table (what-if) capabilities found in almost all spreadsheets.

Acknowledgments

There are many people I thank for giving me the impetus and support to develop these ideas and write this text. The first is Professor Martin Schatz, Dean Emeritus of the Crummer Graduate School at Rollins College. Marty provided the impetus and years of support as these ideas unfolded. Many others have had an impact, including Professor David Monarchi ("I know, Don, formulas look nicer to you, but will the manager agree with you?") of the University of Colorado at Boulder, and Professors Asim Roy of Arizona State University and David Eldredge of Murray State University, who classrooom-tested this material. Valuable contributions have been made by reviewers, including: Stephen Powell, Dartmouth College; Stephan Bloomfield and Dale McFarlane, Oregon State University; Jack Yurkiewicz, Pace University; Rick Hesse, Mercer University; Larry Weatherford, University of Wyoming; Yiannis Glegles, Suffolk University; Dinesh Dave, Appalachian State University; and Paul Gray, Claremont Graduate School.

Special thanks go to four classes of Executive MBA students at the Crummer Graduate school, who have used most of this text in earlier versions. In addition, more than three hundred other MBA students at the Crummer School have had an opportunity to make the text better by pointing out rough spots.

Without a family who so generously shares the love we have all been freely given, this text would never have been completed. May you be rewarded as you become involved in teaching or learning management science using spreadsheets!

Winter Park, Florida
December, 1993

FOREWORD

TO INSTRUCTORS

By tradition, we teach management science topics using algebraic notation and expect managers and students to become proficient in symbolic algebraic manipulation before they learn management science. The author's experience is that we discourage too many people by this process. Yet the traditional course expects the user (the student) to bend to fit the teaching methods of the instructor. The approach in this text is to use a management language, spreadsheets, instead of algebraic notation. The anticipated result: managers and students who learn spreadsheet modeling continue to use these tools in other courses and in their jobs. How often does this happen among students who learn management science using algebraic notation? In summary, the carry-over skills of both spreadsheets and management science are improved by using the methods of this text. It requires a different way of thinking, but the rewards make it worth the effort involved in changing the teaching methods.

Teaching a course that relies heavily upon spreadsheets presents many challenges to the instructor. A major challenge is documenting the logic of a spreadsheet model. Nearly all of the models shown in the text have English-like documentation, which is a useful way to encourage students to replicate these models for themselves. The following additional material is available from boyd & fraser publishing company:

- Virtually every model shown in the text on a diskette for instructors as a `*.WK1` file;
- What's*Best!* software on a 5¼" diskette;
- A linear-only version of What's*Best!* for students with 640K hard-disk computers.

This range of material provides the models that best fit individual classroom demands and the software that satisfies individual student requirements.

A key idea used in developing this text is that it is primarily for "the course in management science" and not "the first course in management science." By teaching as if there is no follow-on course, the text provides managerial usefulness instead of foundations that most students don't build upon.

An important technique in this text is *influence charts* to aid in constructing models. This new term describes a device that has some characteristics of influence diagrams (from decision analysis) and flow charts (from computer programming). Students may be very good at building a spreadsheet model for a system they understand (such as an income statement), because the spreadsheet is a faster way of doing the familiar. But the essence of analysis is addressing new problems, never before seen by the analyst. A student may know that a spreadsheet would help in the analysis, but really doesn't have the experience to construct a useful spreadsheet for a new problem. An influence chart is a structured approach to aid in designing and constructing a spreadsheet model. How often have you known of a situation where hours (days) are spent on a spreadsheet, only to be stopped by the questions "Now what do I have here?" and "Now where do I go?" Influence charting starts with the desired outputs, the most important part of a model, before worrying about "what to multiply and divide, add and subtract."

Flexibility is provided for classes with different backgrounds and ability. For students without much spreadsheet experience, many "spreadsheet tips" appear throughout the text, to stretch students' abilities to use spreadsheets for decision support.

For mature students, several challenging cases are provided. These are often at the end of a chapter, so they can be omitted without losing continuity. While a junior-level undergraduate class would perhaps spend class time dealing with the models in the first part of chapter six, a graduate class might be assigned the Tucker Development Company case at the end of the chapter. In the graduate class, time would be spent discussing models and analysis for Tucker. Another example of this flexibility is the organization of Chapter 9, Optimization Models Involving Time. A beginning course might cover only two models (Hesse Corporation and Highint Company) showing decisions over a finite time horizon. A graduate course might spend only a limited amount of time on these simple illustrations, but spend a great deal of class time looking at models for the Novana Company. This sets the stage for a major case study, Sawgrass Canning Company, which integrates many functions across a business: production planning, purchasing, financing, terms of sale, working capital, and human resources management. A course of some depth can be developed by using these cases:

Chapter 6	Tucker
Chapter 7	Delta
Chapter 9	Novana, Sawgrass
Chapter 10	Hanley Electronics
Chapter 11	Long Plains Fire Services

Chapter 12	Economic Production Quantity, Golden Ear Audio, Efficient Portfolio, Stratified Sample Allocation
Chapter 13	J.D.'s Decision, YumYum Corporation
Chapter 14	Novana revisited, Soft Ideas revisited
Chapter 15	Golden Ear Audio revisited

Note that several cases are repeated. This emphasizes the importance of models, not techniques; the same scenario and very similar spreadsheet models can be used with several different tools of management science. It helps drive home the point that modeling is the unifying concept of management science.

The diskette provided with this text includes the What's*Best!* software (student version) and several other files that are required for various parts of the text. Two of these files, for Golden Ear Audio and North-South Insurance Company, provide large datasets not shown completely in the text. (Why should we show 200 observations in the text, and expect students to key them?) Waiting line formulas are not shown in the text, because there is little learning that takes place by pushing calculator buttons. Instead, the formulas are on two spreadsheets (provided on the diskette) which are discussed in the waiting line chapter (Chapter 16). Finally, students are provided with completed optimization spreadsheets for Rangely Lakes, `RANGELY.WK1` and `RANGELY.WQ1`, which contain the optimization instructions. This scenario is discussed extensively in the text; the file is provided as a concrete example showing all the details that may have been overlooked, misunderstood (or explained poorly?) in developing the first optimization illustration. All of these files may be optionally installed on the student's computer during installation of What's*Best!* by following the on-screen installation instructions.

So let's roll up our sleeves and get on with it!

CONTENTS

1

Management Models for Decisions

Management science is the use of quantitative methods to support managerial decisions. Fundamental to management science is a model, which is a representation of reality. A youngster enjoys a model airplane or a model railroad. An engineer uses a model of an airfoil in a wind tunnel. An architect uses a set of blueprints as a model to show what is to be built. NASA uses computer models of a spacecraft to determine the impact of a new condition that arises during a space flight, so that a new flight plan can be developed.

A manager's model may be as simple as "back of an envelope" calculations leading to a price quotation, or as complex as a large model representing a financial consolidation with a proposed merger partner. A manager uses a model to evaluate alternative courses of action. Within the last decade, managers have become much more directly involved in using a computer in the modeling process. Although computer-based managerial modeling has been around for decades, use of models that were created by the manager, rather than by some other part of the organization (such as data processing, analysis, operations research, or planning), has become widespread in only the last ten years. This relatively new concept of end-user modeling has been fostered by computer software oriented around a spreadsheet.

Why Construct a Model?

Most models are constructed so that the user can see what happens if something changes. Generally, it is more efficient to try out a change on a model than it is to test it in the reality represented by the model. It is easier to test an airfoil in a wind tunnel than on an aircraft flying at 30,000 feet; or to "put the bathroom at this end of the hall" on an architect's drawing to physically build it to see how it affects other parts of the floor plan. During a space flight, it is better to experiment with a new flight plan on a computer simulation model than with the real spacecraft.

A manager uses a model in these same ways. The manager may wish to look at alternative inventory control methods with a model, rather than implementing the methods only to find out that the stockout level has reached unacceptable levels. It is better to experiment with conditions of a new financing plan on a worksheet than in the financial markets, or to determine the staffing requirements with a planning model than by finding out that the company needed a third shift "yesterday."

Modeling for *Ad Hoc* Decisions or Repeated Decisions?

A useful classification of models is by whether the situation being modeled is a "one-time" affair or a repeated situation. A decision to build a new plant using new technology would require an *ad hoc* model, while the monthly budget variance report is repeated monthly. The focus of this chapter is on managerial development of *ad hoc* models. By contrast, computer models that are used repeatedly may be more likely to benefit from an information systems professional who is skilled at tasks such as dressing up the reports and making the software more friendly to a new user.

Two Approaches to End-User Spreadsheet Modeling

How does an end-user (such as a manager) go about constructing a spreadsheet model for a scenario that has never been encountered before, and that may never be encountered again? There are two extreme approaches:

Do it the way I would do it by hand. If a manager's job requires evaluating a proposal, chances are that the manager will eventually be able to figure out how to go about "developing the numbers" that are useful in evaluating a proposal. A model can be constructed that mimics this "traditional" approach, which uually involves starting with detail and following a procedure or set of calculations that eventually (we hope) leads to the "answer" being sought by the modeler.

Build the model "top down" with an influence chart.* This method of modeling requires starting the process with the "bottom line" or the

*Influence charts, as used in this book, have evolved from *influence diagrams* used in the literature of Decision Analysis. The influence charts used here are somewhat similar to the influence diagrams used by Samuel E. Bodily, *Modern Decision Making: A Guide to Modeling with Decision Support Systems* (New York: Mc-Graw-Hill Book Company, 1984). For a description of influence diagrams as used in the literature of decision analysis, see Peter McNamee, *Supertree* (South San Francisco: The Scientific Press, 1992), revised edition. The term *influence chart* has been selected for this book to distinguish the modeling uses of influence charts and the focus on uncertainty in influence diagrams. The word *chart* relates to a *flow chart*, which has long been used as a schematic device developed prior to a computer program. However, influence charts show relationships among variables, while flow charts show flow of control in a computer program. For those with an information systems inclination, it may be useful to view influence charts as a non-procedural equivalent of a flow chart.