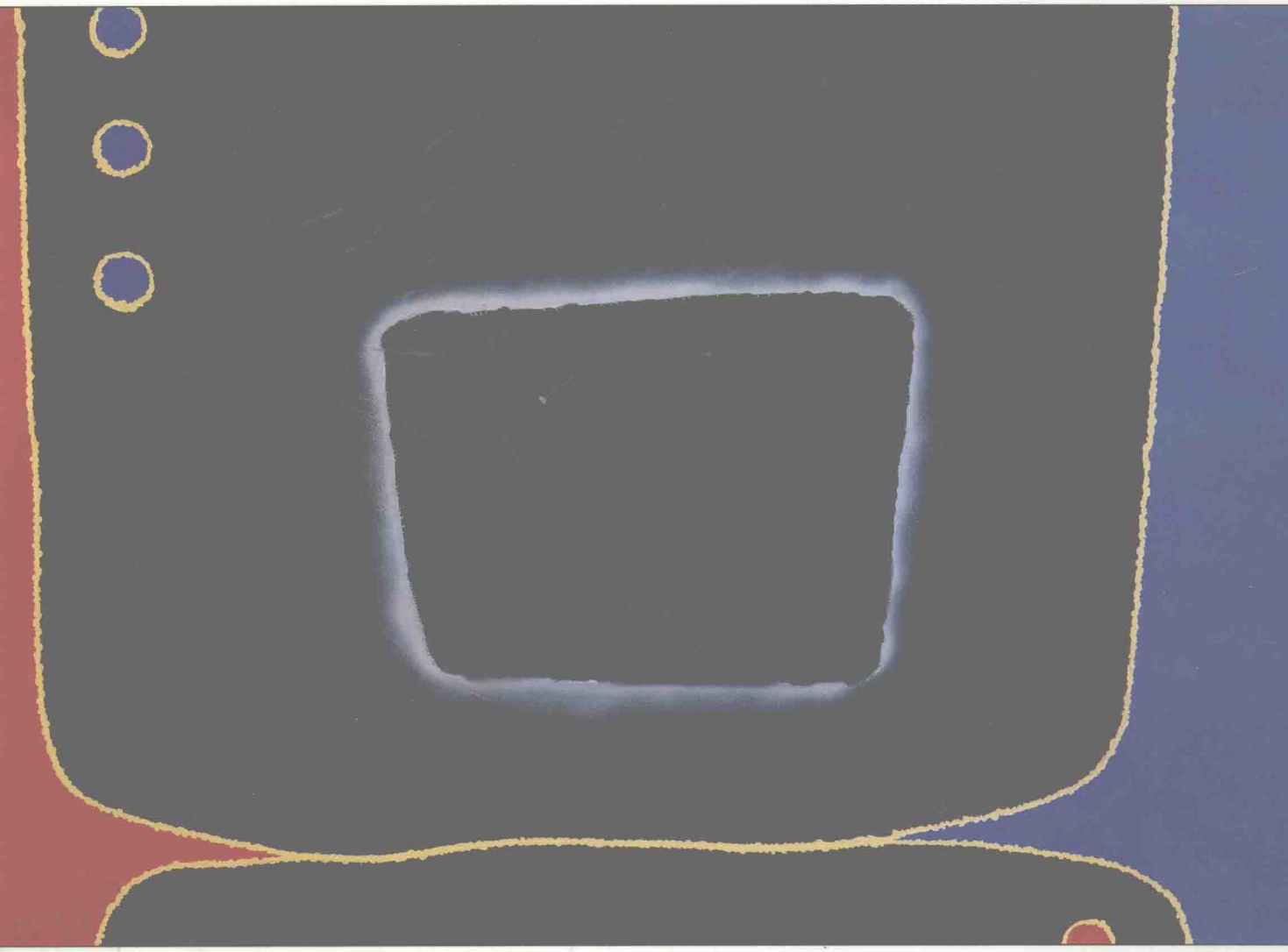
Managerial Spreadsheet Modeling and Analysis



Rick Hesse

MANAGERIAL SPREADSHEET MODELING AND ANALYSIS

Rick Hesse
Mercer University

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Compositor: *Interactive Composition Corporation.*
Typeface: *10/12 Times Roman*
Printer: *Times Mirror Higher Education Group, Inc., Print Group*

Times Mirror
Higher Education Group

Library of Congress Cataloging-in-Publication Data

Hesse, Rick (date)
Managerial spreadsheet modeling and analysis / Rick Hesse.
p. cm
Includes index.
ISBN 0-256-21530-8
1. Problem solving—Computer simulation. 2. Management—Computer simulation. 3. Electronic spreadsheets. I. Title.
HD30.28.H484 1997
658.4'03'00285—dc20 96–27475

Printed in the United States of America
1 2 3 4 5 6 7 8 9 0 WCB 3 2 1 0 9 8 7 6

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To my wife, Gerry, for her support and encouragement
To my son, Dan, for his future

Rick Hesse, November 1996

This book teaches the traditional management science topics using the electronic spreadsheet platform as a very visual, familiar, and friendly tool. All the traditional subject areas are covered, some of which can be solved using standard spreadsheets (Excel, Quattro Pro, Lotus), while others require a spreadsheet solver. This solver add-in was developed by Dan Fylstra of Frontline Systems and is found in Excel 4.0 and higher on Macintosh and Windows machines and Quattro Pro for Windows (QPW) 5.0 and higher. All disk files are in Excel 5.0 Windows format. Macintosh machines should be able to read these disks also.

Class testing has been done from 1992–1995 in business schools at the University of South Florida by A. J. Waltz and at the University of Wyoming by Larry Weatherford. Added for the 1994-1995 academic year was Rick Wilson at Oklahoma State University. The text was used in both undergraduate and MBA and executive courses. The author has used the book at Mercer University since 1991 in the school of engineering in both undergraduate and graduate courses. Almost 500 students have used this text in class testing.

We assume that students, undergraduates, or graduates, have a familiarity with simple algebra, can remember a little about economics (cost, revenue, profit), and know a little about expected values, means, and standard deviation from statistics. In Chapter 10, we use calculus to show how to find the same optimum for several models that the spreadsheet solver finds, but the calculus is not necessary for students to be able to do. Rather, the calculus solutions should give students an appreciation for the work done by the solver and build trust in the answers found by the solver. The last skill necessary for using this book is some simple basic familiarity with PCs and a spreadsheet. The text uses only a few formulas on the spreadsheets and everything else is a matter of formatting, labeling and graphing, saving and reading files, and being able to print output.

Special Features of the Book

This book contains a number of special features. These features are designed to make this text generate a great learning experience in modeling and analysis of real-world problems that arise in business and industry.

1. **Modularity.** This text allows the instructor to cover topics in many sequences. The order I have used starts with deterministic problems (Chapters 2 to 10 and then moves to stochastic problems (Chapters 11 to 15). This text contains more than enough information to

fill two semesters or three quarters of classes, and it is not expected that all chapters will be used in a one-quarter or one-semester course. Figure 1 shows a quick layout of the chapters in this book, with the arrows to indicate when one chapter should precede another. The light shaded chapters cover deterministic models, while the dark shaded ones cover stochastic (or probabilistic) models. You may want to cover the first chapter and then proceed to the deterministic models (Chapters 2 to 10), or after the first chapter, go to the stochastic models (Chapters 11 to 15).

Chapter 1 forms the basis for an introduction to modeling, analysis, and spreadsheets. It sets a good framework for decision makin and problem formulation and solution.

Many instructors may prefer to go on to **Chapters 2 to 4** and cover linear programming first and use the linear-programming simplex solver. Chapter 2 covers basic linear-programming models and their solution, both graphically and by the spreadsheet solver. Chapter 3 is very rich, presenting a wealth of information about postoptimal analysis, and requires a slower pace and careful but rewarding study. Chapter 4 presents a more complex and larger linear-programming models and may be skipped in favor of other material.

Chapters 5 to 9 deal with integer solutions, either implicit (Chapters 5 to 7) or explicit (Chapters 8 and 9) and were arranged by type of problem. They can be taught in any order after coverage of the linear programming in material in Chapters 2 and 3. Chapter 5 covers allocation models, and Chapter 6 covers routing models; both models use a tabular format. Chapter 7 covers some routing and allocation models using a network format. Chapter 8 explains the basis for solving integer programming models and introduces several general integer models. Chapter 9 has several structured integer models.

Chapter 10 contains smaller problems that have nonlinear relationships that should be familiar to students who have taken calculus and business courses and seen inventory models. The default nonlinear gradient search solved is used and smaller spreadsheets are designed so that if students have not been exposed to spreadsheets, they can quickly learn the basics on smaller problems. The solution to the problems can be verified by the formulas derived from calculus and demonstrate both the power and pitfalls of the nonlinear solver. Also included are some simple nonlinear engineering design problems that again can be solved by the spreadsheet solver instead of calculus or other analytical techniques.

Chapter 11 covers decision analysis using tables for single decisions and decision trees for sequential decisions. Some instructors like to use this chapter to lead off the course with the idea of decision making under stochastic conditions for single and sequential de-

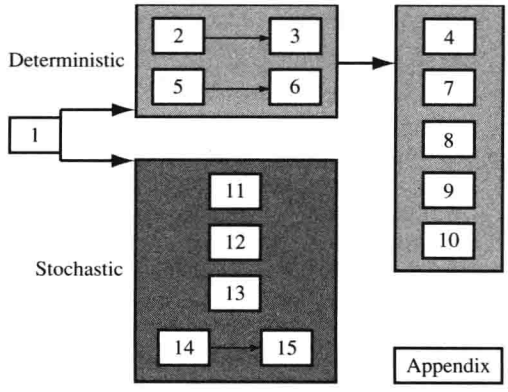

FIGURE 1.
Modular layout of text

cisions. Single decisions use tables for problems such as the "newsboy" problem and multicritera selection. Sequential decisions use decisions tress that can be formatted on spreadsheets and allows for some very nice sensitivity analysis and graphs.

Chapter 12 gives a good introduction to forecasting, both for time series data and causal data. Models covered are moving averages, seasonality, and regression. This chapter is self-standing, and forecasting can be taught anywhere in the curriculum. The approach is from a managerial point of view rather than a statistician's, and the solver regression is compared to the regression add-in found on most spreadsheets.

Chapter 13 revolves around the concept of Markov chains. Markov brand-switching models are taught and spreadsheet templates do all the calculations necessary to find the solution to these problems. No solver is needed for these topics. The idea of a specialized Markov diagram is central to the concept of queues (waiting lines) and some practical applications of finite and infinite queues are covered.

Chapter 14 and 15 use spreadsheets to teach simulation of many different situations and simulate some models covered earlier in the text (newsboy problem and single-server queues). But even these sections review the basics of each model. These chapters have been put at the end of the book, not because simulation is a "technique of last resort," but because it uses some concepts covered earlier. (Also some courses do not have the time to cover this topic.) All sections use regular spreadsheet capabilities to illustrate this powerful and fascinating concept of simulation. These chapters could therefore even lead off the course or be used directly after Chapter 11 (Decision Analysis) to start off the course with the topic of making decisions in the face of uncertainty.

The Appendix explains some of the basic commands, functions, and graphs available in Excel and QPW and also gives detailed instructions for each solver. Although many of these topics are covered in the text, they are also given in the Appendix for purposes of a quick review or reference.

2. **Problem Solving.** A distinctive goal and vital aspect of this text is to teach problem identification and problem solving. We present many types of typical business and industrial problems and highlight several solution techniques throughout the text. These problems are drawn from the areas of production, marketing, sales, finance, and quality control, in both service and production organizations. Chapter 1 outlines a general method of modeling problems. Some problems are covered more than once to show that different models can solve the same problem.

3. **Team Work.** An important aspect of using this text is to allow students to develop their own work teams to do the skill exercises or case problems. The advantage of having two to four people on a team is that students begin to learn how to divide labor and coordinate effort. I allow only one answer from each team, so the team must decide whose work is correct. This is an excellent opportunity to illustrate cooperative learning—a blend of individual effort and teamwork. This imitates the workplace, where a person is required both to be able to work alone and with others; many times, raises and promotions are determined by both individual and group work.

4. **Skill Exercises.** These exercises allow you to check your understanding and reinforce what you have learned in each section by presenting small problems that call for the skills just discussed and are identical or very close to the material just covered. These exercises are opportunities to modify the templates in the immediate section, use them in a different situation, and employ some simple what-if analysis. The data are

fairly straightforward, but the problems require a bit of thinking or investigation. These Skill Exercises differ from the traditional homework problems in that each exercise takes more time to develop but has difference parts to test and challenge the knowledge of the student. I normally assign two skill exercises per class period and have found that this is adequate in keeping students involved and learning the material, especially when I go over the problems during the next class, after the assignment has been handed in.

One of the traps that you as a student can fall into is allowing zealous group members to do all the work and just observe. You may feel that you understand the material when in fact you only recognize it. When it comes time for the tests, you will realize you haven't developed the skill of doing these problems or need a lot more time than the test allows to figure them out.

Each skill exercise has a **CHECK FIGURE** so that you know you are on the right track or may need some help before proceeding to answer questions. These questions are a help to guide you in thinking about the models and the problems presented.

5. Case Problems. These longer problems are found at the end of each chapter, so it is not obvious which techniques(s) can be used to model the situation. Case problems may require the use or construction of more than one model to analyze the situation and may contain ambiguous, ill-structured, and/or extraneous elements. In other words, they are much more like real-life problems than traditional homework problems.

Case problems may require more complicated spreadsheet models that are not just fill-in exercises. Questions are both mathematical (mechanical) and managerial (analytical) and give the opportunity to conduct a managerial analysis of the situation. Thus in addition to giving a feeling for the difficulty of making real managerial decisions, these case problems require more knowledge about the business or industry situation being modeled.

6. Spreadsheet Models. The text includes more than 100 illustrations of relevant spreadsheet models. The models plainly show the elements that go into making decisions, using mathematics and the solver for numerous examples. Each model has a standard format that resolves around just a few key formulas. These formulas are documented in the text in both algebraic and standard spreadsheet format.

7. Student Work Disk. The book comes with a Student Work Disk that has the templates for all the spreadsheet models in the text. You won't have to key in a large quantity of data just to work the examples or spend time building each spreadsheet model. These templates are in Excel 5.0 Windows format and may be placed on a computer network by the instructor.

8. ✔ It Out! Sprinkled throughout the text are opportunities for you to check out the results given in the text on your own spreadsheet. This is an opportunity to "test drive" the model, see how it reacts and responds to different conditions, get the "feel" of the model, and thus "check it out" for your self. These exercises reinforce the learning, either in a lab, at home, or even with laptops in the classroom.

I believe that this book and its approach to management science problem solving will provide a stimulating experience for both instructor and student. Enjoy!

Acknowledgments

This book has been a massive undertaking, forging new ground and helping to create a new vision for managerial problem solving. If this book is successful, it is because I have been privileged to catch the vision for spreadsheet models and solvers from Don Plane of Rollins College, Andy Vazsonyi of the University of San Franciso, and Dan Fylstra of Frontline Systems. I want to also thank Wally Shows of Academic Computing for getting me together with Dan Fylstra. Thanks again to Larry Weatherford, University of Wyoming, A. J. Waltz, University of South Florida, and Rick Wilson, Oklahoma State University, who have seen every version of this text and done extensive class testing for me. An added thanks to Rick Wilson for an excellent job of problem checking and finding numerous errors. However, I accept full responsibility for all errors in this text.

I want to thank the whole staff at Irwin for their help in getting this book published. Thanks to Colleen Tuscher, associate editor, who got the project started; Karen Nelson, project supervisor, who got the book published; and Alisa Watson, editorial coordinator, for her ability to keep things rolling and the communication lines open.

Many people have reviewed the several versions of this text, and their uninhibited comments have been quite instrumental in putting this text into this current form. I want to thank many reviewers at 34 American and Canadian universities who have carefully read and commented on the work in progress. They are from the following universities, business and engineering schools at:

Arkansas State University
Arizona State University
Brigham Young University
Central Michigan University
Clemson University
Cornell University
Dartmouth University
Duke University
George Washington University
Georgia Southern University
Indiana University
Moorhead State University
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Rick Hesse, Hesse_R@Mercer.edu

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C O N T E N T S