DECISION MODELING
WITH MICROSOFT® EXCEL
SIXTH EDITION

CD-ROM

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Decision Modeling with Microsoft® Excel

SIXTH EDITION

Jeffrey H. Moore
Stanford University

Larry R. Weatherford
University of Wyoming

Prentice Hall
Upper Saddle River, New Jersey 07458

To Ashley and Aaron;

To Jenny, for her incredible support and eternal companionship; and Maria, Carolyn, Laura, Bob, Paul, Amy and Josh, for their love and enthusiasm

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About the Authors

Jeffrey H. Moore

Jeffrey Moore joined the faculty at Stanford's Graduate School of Business in 1972 after more than 10 years work as a Communications Engineer, Computer Systems Analyst, and Management Analyst. Since joining Stanford, he has designed and taught courses in the Operations and Information Technology area at the Executive, MBA and PhD levels. He teaches the core course in modeling and analysis and is a popular lecturer in six of Stanford's Senior Executive programs. In his research, he concentrates on decision support systems and computer use by senior executives. He has written more than 40 papers in these and other areas, and has done extensive consulting for private industry both nationally and internationally in the application of information technology and modeling for decision support. He has worked on several courseware projects to introduce Excel for modeling and decision support to graduate level MBA's and executives. This has included work under several grants from Microsoft, IBM, and Hewlett Packard, and early work with Frontline Systems in the testing and development of Excel's Solver, particularly the linear optimization options. In the late 1970s he pioneered one of the first courses to use spreadsheet modeling in a business school, and soon thereafter, orchestrated Stanford's conversion of its modeling core course to spreadsheets, the first major business school to do so. Since that time, he has been involved in the development of modeling and statistical applications of spreadsheets, and has developed GLP, Stanford's Graphical LP Optimizer, and Regress, an Excel-based regression add-in now used at Stanford, Duke, UCLA, and elsewhere. Earlier he served on the INFORMS Business School Educational Task Force which surveyed more than 300 university instructors in the teaching of management science and has made presentations at its conferences on the important role spreadsheets should play in management education. He is also the Director of SunTELL, the Stanford Business School's Technology Educational Learning Laboratory, a facility funded by SUN Microsystems devoted to understanding the use of technology in management and in management education.

In 1996 and again in 1998, he received Stanford's Sloan Teaching Excellence Award for his core course in Decision Support Modeling. Dr. Moore holds a BSEE with specialty in digital circuit design from the University of Cincinnati, a joint MBA/CS degree from Texas A&M University, and a PhD in Business from the University of California at Berkeley. He also holds a Professional Engineer certification (E.E., Ohio).

Larry R. Weatherford

Larry is an Associate Professor in the College of Business at the University of Wyoming. He received his BA from Brigham Young University in 1982, and his MBA and PhD from the Darden Graduate School of Business at the University of Virginia in 1991. He received the Outstanding Teaching Award for the College of Business in his first year as a professor. In the ensuing years he has also earned the "Outstanding Faculty Member" award by Alpha Kappa Psi, the Outstanding Junior Research Award for the College of Business, and more recently the University-wide Ellbogen Meritorious Classroom Teaching Award. He has published 17 scholarly articles in such journals as *Operations Research, Decision Sciences, Transportation Science, Naval Research Logistics, Cornell Hotel and Restaurant Administration Quarterly, International Journal of Technology Management, Journal of Combinatorial Optimization* and *Omega.*

On the practitioner side, he has made over 48 presentations on five different continents to professional organizations. He has consulted with such major corporations as

American Airlines, Northwest Airlines, Lufthansa German Airlines, Swissair, Scandinavian Airlines, Air New Zealand, South African Airways, Unisys Corporation, Walt Disney World and Hilton Hotels, as well as many other smaller corporations.

On the personal side, Larry is married to the lovely Jenny and they have 7 children (yes, they are all from the same union)! Most of his outside interests are centered in his family and church. Any other spare time is spent playing racquetball or golf or reading a fun book.

Preface

TO THE STUDENT OF MANAGEMENT:

The building of explicit models for analysis and managerial decision making has traditionally been called *management science.*

Webster's New World Dictionary defines *oxymoron* as "a figure of speech in which opposite or contradictory ideas or terms are combined." Common examples include sweet sorrow, thunderous silence, jumbo shrimp, sport sedan, bureaucratic efficiency, proprietary standard—you can probably think of many more. And management science?

The same dictionary says that *management* is "the act, art, or manner of managing, or handling, controlling, directing, etc." If management is an art, is management science then an oxymoron—a contradiction in terms?

Not to us!

Science is the process of using observation and testing to establish principles and then using these principles to answer questions. Much of business is based on the same approach. Actuaries use statistical models to set insurance rates. Organizations use discounted cash flow models to make decisions on capital expenditures. Sales executives use models based on demand elasticity to determine prices, and managers use investment models to control their personal investment portfolios.

This book is devoted to modeling concepts that may apply to a variety of different management situations. Indeed, many of the models we will study are generic models. Just as the model for discounting cash flows can be used for situations with different time periods, different interest rates, and different cash flows, so can the models and concepts studied in this textbook be used in widely different situations.

As you work your way through this text, you will find that it is so full of specific example models as to appear to be a modeling cookbook. Our goal in writing this book, however, was not to produce good recipes but to produce good cooks. Thus, you should avoid becoming so immersed in the technical details of the models and their Excel representation that you lose track of the general skills that you must develop to be both a good modeler and a good manager. We believe that you will find this book useful to the extent that you focus upon (1) the *real-world setting* that motivated the creation of the spreadsheet model in the first place, and (2) actively engage in the *model building and analysis.* Doing one without the other is a common, and mistaken, approach employed by managers because it leads to inadequate comprehension needed for good decision making and learning.

It is possible to do the assignments in this book, and not have the concepts affect you in your career. To avoid this, you must work to personally *own* these modeling concepts. To do this requires "hands-on" work with Excel modeling. The responsibility for maintaining this focus rests with you. Learning to be *both* a good modeler and a good manager is far more challenging than learning the mechanics of Excel modeling. We will help by focusing on both management and model, but you can achieve that same focus only with personal effort.

TO THE INSTRUCTOR:

As evident in our message above, Excel-based management science has a lot to offer your students. We believe a good textbook coupled with your teaching and enthusiasm can play a critical role in helping to shape the attitudes of tomorrow's managers towards the proper

use of quantitative modeling in business. Certainly, spreadsheets have become the near-exclusive tool used by millions of managers in analyzing business problems. They now contain many powerful tools that can be used to analyze more sophisticated models and make better decisions. Given the pervasive use of spreadsheets in management, our task is to focus students upon developing their modeling skills—how to "paint" onto the blank canvas of the worksheet to develop helpful, practical business models—and not upon algorithms or mathematical puzzles.

This textbook is designed for introductory courses in applying the Microsoft Excel spreadsheet to management decision modeling at the upper undergraduate, executive, or MBA level. It introduces students to the key ideas of modeling and management decision making that will be important to them throughout their careers. Addressing the needs of readers interested in either general management or more specialized decision science careers, the book emphasizes

- The importance of strong conceptual foundations for all topics, as opposed to just "cookbook" spreadsheet prescriptions
- Role of spreadsheet modeling in the larger context of management decision making, as opposed to algorithmic techniques.

With this in mind, the sixth edition was revised to make it state-of-the-art in the Excel tools that it teaches and to help you make it more relevant to the management careers your students face. With this in mind, content has further shifted away from solution procedures and other mathematical details toward additional case material. For example, over a dozen new cases have been added across the chapters. We have added an expanded number of new problems at the end of most chapters (both basic skill problems and more advanced application problems). For more advanced classes we include Enrichment Topics on the book's CD-ROM for such things as treatment of degeneracy, branch-and-bound algorithms, Evolutionary Solver advanced features, and conditional probability and Bayes' theorem.

We have adopted a very "hands-on" approach to modeling many different challenges a business may face in the areas of operations, finance, human resources, marketing, and the public sector, to name a few. Students strongly prefer this approach because (1) they learn marketable skills they will use immediately in their careers, and more importantly, (2) they develop valuable modeling habits and insights of longer-term benefit. Many students have called us to say that this was one of the most valuable courses they took in college because it combines tangible applications and modeling philosophy with learning by doing.

The book has a strong focus on models—what they are, how they are created, how they are used, what kinds of insights they provide—and on the critical importance of managerial judgment in utilizing those insights. At the same time, for readers interested in the more in-depth aspects of the subject, there is an unparalleled treatment of optimization and decision analysis techniques.

In addition to revising the pioneering chapter on general modeling with Excel introduced in the previous edition, this edition has added two entirely new chapters. To complement our coverage of Monte Carlo simulation, a new chapter introduces discrete event simulation with Excel and with Extend. A new chapter on implementation that focuses on organizational and management issues surrounding institutionalization of a model has been added, which includes an extensive real-world case for class discussion of this critically important topic. We have also significantly revised two chapters—Project Management has been expanded to include both approaches to project modeling, activities on arcs and activities on nodes via use of the software package, MS Project for Windows and the Monte Carlo simulation chapter has been expanded to include examples on optimization of Excel simulation models via OptQuest.

Continuing the fine tradition of previous editions, the text offers unequaled coverage of optimization and introduces the concept of a "theme case" at the end of each chapter (Ebel Mining) in which a multi-part case's model is made increasingly more sophisticated in building block fashion as more concepts are developed in chapters.

The merging of topics begun with the previous edition has been continued in this edition in recognition of the increasing teaching pressure to streamline topic coverage. This edition combines the previously separate chapters on graphical and sensitivity analysis into a single integrated chapter that introduces SolverTable. Developed at Stanford's GSB five years ago, SolverTable is an add-in that extends Excel's Data Table to perform parametric analysis, including tabulations of Sensitivity Report values, of optimization models.

Finally, this edition increases its coverage of chapter examples, particularly by adding simpler, introductory models to facilitate learning, and maintains its Macintosh-friendly tone of documenting differences for those students modeling in Excel for Macintosh. Chapters are filled with marginal "Tips" to help students avoid pitfalls in Excel while avoiding a break in the conceptual developments in the chapters. In addition, detailed appendices on Solver and the special features of Excel for modeling not normally covered in mechanics-of-spreadsheets courses have been expanded to enable the student to improve their spreadsheet skills and gain a greater appreciation for the modeling capability of Excel.

Spreadsheet applications and examples in Microsoft Excel, including the use of popular spreadsheet add-ins (Solver, Crystal Ball, @Risk, and TreePlan), are integrated throughout as the modeling paradigm. This edition introduces Evolutionary Solver, based upon a genetic search algorithm, to illustrate applications that previously frustrated student attempts to analyze highly nonlinear models that make use of Excel's nonsmooth functions, such as =IF( ).

Considerable attention has been paid to the procedural (almost tutorial) steps to build and analyze decision-making models in Excel. The emphasis again is "hands-on" use of Excel and its add-ins. Updated to include the latest Excel version, Excel 2000, the book provides more than 500 screen "shots" of Excel models. (Most examples are applicable to earlier versions of Excel.) Importantly, the book includes more than *ten* software application packages students will use long after the course is completed:

- A graphic visualization program, GLP, for interactive optimization of linear programming models—software included with the book.
- Premium Edition Solver for Education including infeasibility and nonlinear diagnostic reports to aid students in debugging their optimization models—software included with book.
- SolverTable add-in software for parametric analysis, including Sensitivity Report values, of optimization models—software included with book.
- Evolutionary Solver (part of Premium Edition Solver for Education) for performing genetic search on models having highly nonlinear or nonsmooth relationships—software included with book.
- *Professional* version (140 day time-limit) of the Monte Carlo simulation add-in, Crystal Ball—software included with the textbook. This version includes the Monte Carlo simulation optimizer OptQuest.
- Decision analysis add-in software, TreePlan—software included with the book.
- Excel templates for queuing model calculations—software included with book.
- The discrete event simulation package Extend LT—software included with textbook.
- The Manufacturing and Business Process Reengineering simulation library extensions to the simulation package Extend LT—software included with textbook.
- Microsoft Project 2000 (120 day time-limit)—software included with the book.

The book is divided into four parts: the first deals with general modeling issues, the second with deterministic models, the third with probabilistic (stochastic) models; and the fourth with implementation issues for applying models in organizations. This provides a logical organizational framework for the material while allowing for greater emphasis on and enhanced coverage of currently "hot" areas such as genetic optimization, AHP, Monte Carlo simulation, discrete event simulation, multi-objective decision making, and the general use of spreadsheets in modeling. There is more material than can be covered in a typical first course. We believe our organization of topics allows each instructor the flexibility to tailor their course to different audiences and needs.

ACCOMPANYING MATERIALS

New copies of the book include a CD-ROM containing the following software and courseware at no extra charge:

- The graphic visualization program, GLP, for interactive optimization of linear programming models for the material in Chapters 4 and 6.
- Premium Edition Solver for Education including infeasibility and nonlinear diagnostic reports for the material in Chapters 3, 4, 5, 6, and 7.
- SolverTable add-in software for parametric analysis of optimization models for the material in Chapters 4, 5, 6, and 7.
- Evolutionary Solver (part of Premium Edition Solver for Education) for performing genetic optimization for the material in Chapter 7.
- *Professional* (140 day) version of the Monte Carlo simulation add-in, Crystal Ball for the material in Chapter 9. This includes the Monte Carlo simulation optimizer OptQuest (also for Chapter 9).
- Decision analysis add-in software, TreePlan for the material in Chapter 8.
- The discrete event simulation package Extend LT for the material in Chapter 10.
- 120 day *Evaluation* version of Microsoft Project 2000.
- Excel templates for queuing models.
- Excel spreadsheet files for all in-text examples and any relevant data for end-of-chapter problems and cases.

Supplementary items for text adopters:

- Excel Solutions (for the Instructor) to every example, problem, and case in the book. Instructors may use these as is, take out some of the detail, or modify them as desired.
- Presentation slides for each chapter in PowerPoint with the appropriate Excel spreadsheets (ISBN: 0-13-040631-7)
- Access to protected Web Page for more timely supplementary materials and additional cases.
- Instructor's Solutions Manual (ISBN: 0-13-040627-9)
- Test Item File (ISBN: 0-13-040629-5)
- Prentice Hall Custom Test for Windows (ISBN: 0-13-040620-1)

ACKNOWLEDGMENTS FOR THE SIXTH EDITION

We would like to thank the original authors of the first four editions, Gary Eppen and F.J. Gould, joined in later editions by Charles Schmidt, for their arduous efforts in creating a classic textbook that was worthy of being revised.

We would like to thank our editor, Tom Tucker, for his commitment to bringing this revision to pass and for his patient good humor as deadlines raced by. We believe if it wasn't for his guidance and direction, the book would not be nearly the product that it is.

We would like to thank our many reviewers of this edition (see the list below) for their insightful comments and ideas. This is a much better book because of them.

We thank the more than 300 instructors who participated in the extensive INFORMS Management Science Teaching Survey. Their comments and suggestions have validated many of the changes made in this edition.

We would also like to thank our secretaries, Stephanie O'Dell and Hiromi Yampol, for the long hours of dedicated service in the editing and logistics support a project such as this requires. We also thank Kevin Lewis for his help and the creation of numerous problems and examples. The Sloan Executives at Stanford deserve our thanks for pilot-testing this edition of the book. In particular, we thank Professors James Patell and Michael Harrison for class-testing some of the newest material in this book.

We are grateful to Professors Charles Bonini, Evan Porteus, Krishnan Anand, James Patell and Haim Mendelson for agreeing to make their case material available in this book, and to Professor Stephen Bradley for his cooperation in creating the implementation case. We thank Professors David Ashley and Mike Middleton for providing the queuing templates and the TreePlan software, respectively.

Also, we would like to thank Daniel Fylstra and John Watson of Frontline Systems and Software Engines for making Solver a reality. They have been a joy to work with. We are especially grateful to Dan for making Solver Premium Edition for Education available to students as a generous and gracious commitment on his part to facilitating management education.

Finally, at Microsoft, former Stanford students, Steve Ballmer and Pete Higgins, deserve thanks for their instrumental roles in creating the Excel tools that have made it the preferred choice for modeling and analysis by managers. Their cooperation with and receptivity to suggestions from academics in determining Excel's and Solver's product design and feature set is a model that we wish more software companies would follow.

We hope you find that this text and its supporting materials enhance your teaching efforts. We always like to hear from you—especially when it's to pass along your ideas for how the text can be improved—so, please feel free to send along your reactions.

Jeffrey Moore, Palo Alto, CA
Email: moore_jeffrey@gsb.stanford.edu
Phone: (650) 723-4058
FAX: (650) 725-7979

Larry R. Weatherford, Laramie, WY
Email: lrw@uwyo.edu
Phone: (307) 766-3639
FAX: (307) 766-3488

REVIEWERS FOR THE SIXTH EDITION

Sid Deshmukh, Northwestern University; James Drosen, North Michigan University; John Kottas, College of William and Mary; Rita Kumar, California State University-Northridge; Benjamin Lev, University of Michigan-Dearborn; Jerrold May, University of Pittsburgh; Danny Myers, Bowling Green University; Gary Reeves, University of South Carolina; Sam Roy, Moorhead State University; David A. Schilling, The Ohio State University; Glen Zabowski, McGill University

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