Management Science for Decision Makers

LARRY M. AUSTIN

PARVIZ GHANDFOROUSH



MANAGEMENT SCIENCE FOR DECISION MAKERS

LARRY M. AUSTIN

Texas Tech University

PARVIZ GHANDFOROUSH

Virginia Polytechnic Institute and State University

WEST PUBLISHING COMPANY

MINNEAPOLIS/ST. PAUL

NEW YORK

LOS ANGELES

_____ SAN FRANCISCO

WEST'S COMMITMENT TO THE ENVIRONMENT

In 1906, West Publishing Company began recycling materials left over from the production of books. This began a tradition of efficient and responsible use of resources. Today, up to 95 percent of our legal books and 70 percent of our college and school texts are printed on recycled, acid-free stock. West also recycles nearly 22 million pounds of scrap paper annually—the equivalent of 181,717 trees. Since the 1960s, West has devised ways to capture and recycle waste inks, solvents, oils, and vapors created in the printing process. We also recycle plastics of all kinds, wood, glass, corrugated cardboard, and batteries, and have eliminated the use of styrofoam book packaging. We at West are proud of the longevity and the scope of our commitment to our environment.

Composition: Carlisle Communications Artwork: Brian Betsill

Text design: Melinda Grosser for silk

Production, Prepress, Printing and Binding by West Publishing Company.

COPYRIGHT © 1993

By WEST PUBLISHING COMPANY 610 Opperman Drive
P.O. Box 64526
St. Paul, MN 55164-0526

All rights reserved

Printed in the United States of America

00 99 98 97 96 95 94 93 8 7 6 5 4 3 2 1 0

Library of Congress Cataloging-in-Publication Data

Austin, Larry M.

Management science for decision makers / Larry M. Austin, Parviz Ghandforoush.

p. cm.

Includes bibliographical references and index.

ISBN 0-314-01243-5

1. Management science. I. Chandforoush, Parviz. II. Title.

T56.A88 1993

658.4'03 - dc20





Dedicated to Jill and Terri, who make it all worthwhile. L.M.A. and P.G.

PREFACE

In most present texts on quantitative methods of management science/operations research (MS/OR), there is a strong emphasis on understanding the mathematical details of algorithms used to solve models introduced by the text. The traditional approach to teaching algorithms is "hand solution." Before the proliferation of computers and the availability of sophisticated software, such an emphasis was necessary so that we could solve the models.

This emphasis compromised other equally appropriate emphases, such as:

- Developing problem solving and model formulation skills
- Understanding real-world problems (instead of textbook problems whose models we can solve by hand calculation methods)
- Appreciating the assumptions that underlie the models (and their methods).

With computers and software for solving MS/OR models accessible to virtually everyone, we need to reassess the emphasis on hand solution of models.

We intend this textbook for use in graduate-level management science courses for prospective or practicing executive decision makers. Such courses typically are required in the second year of master's degree programs, such as Master of Business Administration (MBA); Master of Science (MS) in Business Administration, Economics, or Industrial Engineering; and Master of Industrial Management (MIM); etc. For convenience, we refer to such programs in this preface and throughout the book by the generic term "MBA."

An MBA student needs to learn how to formulate and analyze models to enhance his or her problem solving and decision-making abilities, and is much less concerned with the technical details of algorithms used to solve these models. Therefore, we geared the organization and substance of this book, toward problem formulation, model conceptualization, and problem analysis—not hand solution of small textbook models.

For all practical purposes, knowledge of management science required by the practicing manager should be identical to that required by the MBA student. Decision makers need to have substantive understanding of what models are available, how to build them, and how to use the resulting solutions as an aid to problem solving. Consequently, this text would serve equally well as an MBA textbook or as a reference book on MS/OR models for the practicing manager.

In view of the specific pedagogical needs of the MBA student and the practicing manager, we adopted the following goals and criteria for the design of this text.

- To emphasize the development of problem solving and model formulation skills, including:
 - a) Recognizing how and when a particular type of model can be of value; and
 - b) The ability to construct a model of the problem.
- To carefully consider the assumptions that underlie each model and its associated algorithm(s).

- To introduce the student to a variety of realworld or realistic problems and their models through the use of complex minicases.
- To articulate the art and science of decision analysis under conditions of certainty, risk, and uncertainty.
- To employ a managerial perspective that focuses on decision making rather than mathematical solution techniques.

In addition, this book places a strong emphasis on "what if" in addition to the usual "what's best." We demonstrate to MBA students how to use management science models to gain insight into problems.

In this text we do not "force" a quantitative approach to decision making and management. Rather, we include decision factors that are *intuitive*, *subjective*, *judgmental*, *and unquantifiable* as an inherent component of each real-world minicase. We illustrate how only a proper mix of quantifiable and nonquantifiable considerations can lead to a satisfactory solution strategy.

We treat decision making at all levels of the organizational hierarchy. At each level, modeling begins with an assessment of which factors or variables are within the decision maker's capacity to influence and which factors the decision maker can only observe. All model formulations, therefore, begin and end with a specified decision maker's perspective of the problem. Nor do we avoid the complexity that usually accompanies real-world decision making.

MBAS AND COMPUTER SOFTWARE

It is clear that successful use of this textbook for graduate courses depends heavily upon the availability of microcomputer software that implements the various MS/OR algorithms. There are more than a dozen such packages for IBM-compatible microcomputers, to include D&D [1], Management Scientist [2], STORM [3], QSB + [4], MSS [5], and ORS [6]. Rather than arbitrarily selecting one of these packages as our vehicle in this book, we invoke the fictitious package that we call SAMS (Simulated Algorithms for Management Science). SAMS is a generic approach to modeling with microcomputer software that will permit adopters of this text to select their preferred packages in the market. It has a spreadsheetlike input mechanism

and report format similar to those of most available packages.

ORGANIZATION OF THE TEXT

The text begins with a discussion of modeling as both art and science. We discuss the importance of modeling, and introduce the notation used in the text. We characterize the model building process in some generality. In detail, we discuss the criteria by which the manager classifies the problem and chooses an appropriate model to represent it. Chapter 1 presents all of these ideas. The remainder of the text consists of four parts:

DECISION MAKING UNDER CERTAINTY

Chapters 2 through 6 are about decision making under certainty. The first four chapters address deterministic mathematical programming models—linear programming, integer programming, network programming, and nonlinear programming. Chapter 6 deals with deterministic dynamic programming.

DECISION MAKING UNDER RISK

Chapters 7 through 12 describe models related to decision making under risk. Chapter 7 discusses matrix decision models, decision trees, expected value and opportunity loss, Bayesian analysis, and the concept of economic utility. Chapter 8 deals with queueing (waiting-line) models, while Chapter 9 describes the use of simulation in the decision environment. Chapter 10 discusses Markov chains. Chapter 11 describes the extension of probabilistic concepts to project management (PERT). Chapter 12 introduces basic principles of scientific inventory management.

DECISION MAKING UNDER UNCERTAINTY

Chapters 13 through 15 discuss models for decision making under uncertainty. Chapter 13 covers the classical matrix decision model. Chapter 14 introduces modeling with multiple objectives and goal programming. Chapter 15 presents some useful graphical tools and multiattribute choice models that don't "fit" elsewhere in this part of the text.

MANAGEMENT SCIENCE AND THE FUTURE

The Epilogue presents our view of the "high tech" future of 2000 A.D.

ORGANIZATION OF EACH CHAPTER

Most chapters follow a uniform format to give continuity and coherence to the book. A typical chapter consists of the following sections:

- a. Underlying Assumptions. Here we give managerial meaning to such concepts as linearity and multistage decision making.
 We also describe problem classes appropriate for this type of model.
- b. Modeling. Here we describe the models verbally and present an intuitive description of the corresponding mathematical representations. We omit terms that have to do with the algorithm(s) used to solve the model (e.g., in linear programming—artificial variable, pivot, entering and exiting variable, revised SIMPLEX). This section devotes particular attention to how we formulate models of this type, and what the data requirements are.
- c. Solution Approaches. Section c is an intuitive description of the algorithm(s) used to solve models of this type. In this section, we describe the algorithms by analogy or by use of graphical and tabular illustrations.
- d. Developing Alternative Solutions. Here we deal with sensitivity studies and parametric analyses of model solutions that we can perform to assist in developing alternative solutions to the problem.
- e. State of the Art Topics. Section e briefly describes state-of-the-art topics, such as computational considerations related to problem size and potential difficulties encountered during computer implementation. Our purpose in including these brief discussions of advanced models is to make potential and practicing managers aware that the models exist. To discuss these topics in detail would take us well beyond the scope of this book; to omit them would convey an incomplete—and therefore erroneous—impression of the dynamic nature of management science.

- f. Minicases. In this section, we present from two to five minicases—hypothetical and actual short cases that illustrate applications of the model(s) to real or realistic problems. Several cases are adaptations of term project reports submitted by our MBA students over the years at Virginia Tech and Texas Tech. Not all minicases report successful applications—some describe unsuccessful applications and why the applications were unsuccessful. These minicases reflect the complexity of the real-world decision environment.
- g. Summary. Section g summarizes the material presented in the chapter and provides an overview of the chapter contents.
- h. Problems for Analysis and Practice Models. In this section, we first present end-of-chapter problems that will stimulate and challenge MBA students. We include "unworked" minicases that expose students to some of the complexities of problems they will encounter after graduation. Then we provide some small, unadorned practice models that MBA students can use to become familiar with available software.
- References and Additional Reading. Section i contains chapter references and suggestions for additional reading.

THE PHILOSOPHY OF THE ROOK

This book emphasizes the problem-definitional aspects of MS/OR usage, and recognizes a need for coping with the complexity of the real-world decision environment. It treats such complexity with candor, and it presents tools for characterizing and analyzing the complexity of the real world. It takes a managerial perspective of decision analysis.

Although the writing style is informal, this is a deadly serious book. It is not about algorithms. It is about the difficult, complex, and frustrating process of managerial decision making. If the book has a "theme," we can best describe it by the following phrase, which we repeat several times herein:

MODELS DON'T MAKE DECISIONS— MANAGERS DO.

ACKNOWLEDGEMENTS

For their incisive comments on the drafts of the book and for the raw materials for several minicases, we are grateful to our MBA students—present and past—at Texas Tech and Virginia Tech. We wish also to thank our respective universities for their logistical support and our faculty colleagues for their help and encouragement.

In preparing this book for publication, we were extremely fortunate to have the advice and assistance of some excellent reviewers. Special thanks go to Steve Bechtold at Florida State University, Warren Boe at the University of Iowa, Mike Hanna at the University of Houston—Clear Lake, Don Harnett at Indiana University, Lori Kaplan at the University of Tennessee—Knoxville, Bill Pinney at the University of Texas—Arlington, Alan Raedels at Portland State University, Steve Replogle at Arkansas State University, and Rick Wilson at Oklahoma State University.

Special thanks are in order to the professionals at West—particularly Rick Leyh, Jayne Lindesmith, and Jessica Evans.

L.M.A., P.G.

References

- 1. Anderson, D., D. Sweeney, and T. Williams. *Management Scientist*. St. Paul: West, 1991.
- Chang, Y., and R. Sullivan. QSB+: Quantitative Systems for Business Plus. Englewood Cliffs, NJ: Prentice-Hall, 1989.
- Dash, G. and N. Kajiji. Operations Research Software. Homewood, Ill.: Richard D. Irwin, 1988
- Dennis, T., and L. Dennis. Microcomputer Models for Management Decision-Making 2d ed.). St. Paul: West, 1988.
- Emmons, H., and D. Flowers. STORM Personal Version 3.0. Englewood Cliffs, N.J.: Prentice-Hall, 1991.
- Nelson, T. The Management Science System. Homewood, Ill.: Richard D. Irwin, 1988.

CONTENTS

PREFACE vii

1.	Pro Re			
PROBLEMS, MODELS, DECISIONS, & SYSTEMS 1				
Problems and Decisions 2	P			
Model Classification 2				
Model Building—An Art and a Science 5				
Step 1: Statement of the Purpose 6	CI			
Step 2: Clarification of the Values 7	UI			
Step 3: Determination of the System 7				
Step 4: Identification of the Problem 8				
Step 5: Formulation of the Model Structure 9				
Step 6: Collection of the Data 9	LI			
Step 7: Validation of the Model 9	M			
Step 8: Selection of the Algorithm 10	Un			
Step 9: Derivation of Feasible Policies 11	011			
Step 10: Determination of the Most Appropriate Policy 11				
Step 11: Implementation of the Policy 12	Bu			
Notation 13				
Some Classical Problems in Management Science 14	Mo			
Resource Allocation Problems 14				
Capital Investment Decisions in Risky Environments 15 Decisions in Risky Decisions in Risky				
Caveats and Comments on Building and Using Models 16				

Summary	18	
Problems	19	
References	and Additional Reading	21

PART ONE DECISION MAKING UNDER CERTAINTY (DMUC) 23



LINEAR PROGRAMMING MODELS 26

Underlying Assumptions 26
Additivity 27
Divisibility 27
Building LP Models 27

An Orderly Approach to Model Building 28

Model Formulation: Two Examples 31 LO-CAL Candy Company 32 Teletronix Industries, Inc. 34 The SIMPLEX Algorithm: An Intuitive Description 36

> The SIMPLEX Algorithm 37 A Graphical Example 38

Developing Alternative Solutions 40	Zero-One Models 112
Standard Computer Output 41	Developing Alternative Solutions 112
Decision Variables 43	Alternatives with Branch and Bound 112
Slack Variables 43	Alternatives with Cutting Planes 112
Ranging Analysis on Resource	Sensitivity Analysis in ILP 112
Availability 45	Extensions of ILP Modeling 114
Ranging Analysis on Objective Coefficients 45	Reduction to Zero-One Models 114 Traveling Salesman Model 115
"What If" Analysis 46	<u> </u>
A Caveat for Decision Makers 46	MINICASE: Disk-o-Tech 117
Teletronix Industries Revisited 47	MINICASE: BLL, Inc. 121
Extensions of the SIMPLEX Method 49	MINICASE: Backpacking 123
Some Bits and Pieces 49	Summary 128
Unbounded and Infeasible Solutions 50	Problems for Analysis 128
Duality Theory 51	Practice Models 141
Some Advanced Topics 52	References and Additional Reading 144
Lower-Bounded Variables 52	
Upper-Bounded Variables 53	
Dantzig-Wolfe Decomposition 53	4.
MINICASE: Wiseacre 55	
MINICASE: William Hill Distillery 60	MODELING WITH NETWORKS 145
MINICASE: Incremental Profit Program 64	Underlying Assumptions 147
MINICASE: Racquet 67	Network Modeling and Algorithms 147
MINICASE: Security 71	Shortest Route Through a Network 147
Summary 74	Longest Route Through a Network 147
Problems for Analysis 75	Network (CPM) 150
Practice Models 88	Minimal Spanning Tree Model 154
References and Additional Reading 90	Optimal Network Flow Model 157
received and raditional reading 70	Transportation Models 158
	Assignment Models 163
3.	Transshipment Models 164
	Comments on Network Modeling 165
INTEGER (LINEAR)	Developing Alternative Solutions 166
PROGRAMMING MODELS 92	Descriptive Network Models 166
	Optimizing Network Models 168
Underlying Assumptions 92	State of the Art in Network Modeling 168
Integer Modeling 93	The Chinese Postman Model 168
Natural Integer-Valued Variables 93	Multicommodity Network Flows 169
Modeling with Surrogate Integer Variables 94	Imbedded Networks 169
Modeling with Zero-One Decision	The Min-Cut/Max-Flow Theorem 169
Variables 103	MINICASE: Meter Readers 170
Solution Approaches:	MINICASE: Center for Professional
An Intuitive Description 106	Development (CPD) 172
Branch and Bound 107	MINICASE: POLKA 175
Cutting Planes 110	Summary 177

Problems for Analysis 177 Practice Models 187 References and Additional Reading 189



NONLINEAR PROGRAMMING MODELS 191

Underlying Assumptions 192 Nonlinear Modeling 193 A Pricing Model 193

An Inventory Control Model 195

A Scrap Minimization Model 197

A Container Cost Minimization Model 197 Genesis of NLP Models 198

NLP Solution Approaches: An Intuitive Description 199

Indirect Methods 199 Direct Methods 200 Linearization 200 Miscellaneous Methods 204

Developing Alternative Solutions 204

State of the Art in NLP 205

MINICASE: Colossus of Roads 206 MINICASE: Beau-Kay, Inc. 210

Summary 214

Problems for Analysis 215

Practice Models 222

References and Additional Reading 223



DISCRETE DYNAMIC PROGRAMMING MODELS 224

Underlying Assumptions 224 Multistage Modeling 226

> Time-Sequenced Decisions 226 Separability 227

Order-Independent Allocation 228

Dynamic Programming: An Intuitive Description 228

The Elusiveness of Recursive Optimization 230

The "Curse of Dimensionality" 231

Developing Alternative Solutions 232

State of the Art in Dynamic Programming 232

Continuous Dynamic Programming 233 Nonsequential Multistage Optimization 235

MINICASE: Air Traffic Control 235 MINICASE: Cabana Bananas 238 MINICASE: Touring Europe 241

Summary 243

Problems for Analysis 244

Practice Models 248

References and Additional Reading 249

PART TWO DECISION MAKING UNDER RISK (DMUR) 251



A STRUCTURE FOR DECISION MAKING UNDER RISK 254

Structuring the Decision Environment 254 A DMUR Model 255

> Assessing State Probabilities 255 Sequential Decision Processes 257

Decision Criteria for DMUR Models 257

The Expected Monetary Value Criterion 258 The Expected Opportunity Loss

Criterion 259

The Value of Information 260

The Value of Perfect Information 260

The Value of Imperfect Information 261

An Optimizing Algorithm for Decision Tree Models 264

Sensitivity Analysis of DMUR Models 266	State of the Art in Queueing Models 314
Analysis of Prior Probabilities 267	Some General Parameter Relationships 314
Dominated Alternatives 267	Advanced Models 315
The Posterior Distribution 267	MINICASE: ICQ 315
The Concept of Economic Utility 268	MINICASE: Gourmet 318
An Underlying Assumption 268	Summary 320
Utility Functions 269	Problems for Analysis 321
Building Utility Functions 270	Practice Models 326
State of the Art in DMUR 271	References and Additional Reading 326
Continuous Prior Distributions 272	Appendix: Closed-Form Analytical Results for
The Newsboy Model 273	Two Models 327
On the Frontier 274	
MINICASE: Jack Legg Associates 275	
MINICASE: High Tor 280	9.
MINICASE: King Cotton 282	
MINICASE: D-Day 284	DISCRETE SIMULATION MODELS
Summary 287	328
Problems for Analysis 287	Underlying Assumptions and Definitions 332
Practice Models 297	Activities and Events 332
References and Additional Reading 298	Entities and Attributes 333
	Approaches to Discrete Simulation 334
	Mechanics of Discrete Simulation Model
8.	Formulation 334
	A Neighborhood Grocery Store Example 334 Random Number Generation 338
WAITING LINE (QUEUEING)	Probability Distributions 339
MODELS 300	Sampling in Simulation 342
II-deling Assumptions 200	Discrete Simulation Results 344
Underlying Assumptions 300 The Calling Population Subsystem 301	Solution Approaches: An Intuitive
The Queueing Subsystem 301	Description 344
The Service Facility Subsystem 302	General Purpose Simulation
The Integrated Queueing System 303	System (GPSS) 344
Building Queueing Models 303	SIMSCRIPT II.5 346
Some Useful Notation 307	SLAM—A Simulation Language for Alternative Modeling 347
Some Caveats in Using Queueing	State of the Art in Simulation 348
Models 307	Visual Interactive Simulation 348
Solution Approaches: An Intuitive	Knowledge Engineering 348
Description 308	Continuous Simulation 348
Notation 308	MINICASE: Savin E. Lavin, Inc.
Some Known Results for Queueing Models 308	(Continued) 349
Developing Alternative Solutions 312	MINICASE: Cabana Bananas (Revisited) 350
Arrival and Service Time Distributions 312	Summary 356
Arrival and Service Rates 313	Problems for Analysis 357
An Example of Sensitivity Analysis 313	References and Additional Reading 363

Appendix: Continuous Simulation Models 365



MODELING WITH MARKOV CHAINS 370

Underlying Assumptions 371

Modeling with Transition Matrices 372

Solution Approaches: An Intuitive

Description 373

Recurring Markov Processes 373 Transient Markov Processes 375

Developing Alternative Solutions 377

State of the Art in Markov Chain Analysis 377

Time of First Passage 377

Dynamic Programming in Markov Chains 378

MINICASE: An Officer and a Gentleman 379

MINICASE: Lemmon Rent-a-Car 383

Summary 385

Problems for Analysis 386

Practice Models 391

References and Additional Reading 392



PROJECT SCHEDULING 393

Underlying Assumptions 393

The Beta Distribution 395

Approximation to the Beta Distribution 395

Modeling with PERT 396

Solution Technique: An Intuitive

Description 398

Sensitivity Analysis 400

PERT/COST 401

Project Management with PERT 401

Advanced Concepts in Project Scheduling and Management 402

GERT and Q-GERT 402

PERT-Simulation 402 Some Caveats 403

MINICASE: Audit Trail 404 MINICASE: GYRO 410

Summary 412

Problems for Analysis 413

Practice Models 415

References and Additional Reading 416



12.

INVENTORY MANAGEMENT 418

Types of Inventories 418
Types of Inventory Models 419
Underlying Assumptions 419

Demand 419 Order Quantity 419

Lead Time 419

Procurement Costs 420

Operating Costs 420

Modeling an Inventory System 421

Procurement Cost 422 Holding Cost 422 Ordering Cost 422 Total Cost 423

Solution by Discrete Simulation 423

Closed-Form Solutions 424

The Simulation Model 427

Constraints 423

Advanced Concepts in Inventory Management 427

> Multiechelon Inventory Models 427 Periodic Review Inventory Models 428 Material Requirements Planning 429 Just-In-Time Production System 430

MINICASE: EOQ at AFLC 430

MINICASE: Keep on Truckin' 433

Summary 437

Problems for Analysis 438

Practice Models 439

References and Additional Reading 440

Appendix: Incremental Price Breaks,

No Constraints 441

PART THREE DECISION MAKING UNDER UNCERTAINTY (DMUU) 443



CLASSICAL DECISION MODELS UNDER UNCERTAINTY 445

Underlying Assumptions 445

Modeling Under Uncertainty 446

The MAXIMIN Criterion 446

The MAXIMAX Criterion 448

The MINIMAX Regret Criterion 448

Deriving Useful Solutions 452

Risk and Utility 452

State of the Art in Modeling Under

Uncertainty 452

MINICASE: Apteryx Aircraft Company 453

The Insufficient Reason Criterion 451

MINICASE: D-Day Revisited 456

Summary 460

Problems for Analysis 460

Practice Models 462

References and Additional Reading 464



MODELING WITH MULTIPLE OBJECTIVES 465

Underlying Assumptions 465

Matrix-Vector Notation 466 Commensurable Functions 467 Incommensurable Functions 467

MOLP Modeling 468

MOLP Models Requiring Commensurability 468 MOLP Models Not Requiring Commensurability 472

Solution Approaches: An Intuitive Description 477

The MAXIMIN Model 478

The Linear Combinations Model 480
The Preemptive Goal Prioritization

Model 480

The Preemptive Goal Programming

Model 481

Developing Alternative Solutions 481 State of the Art in MOLP 482

Utility Transformations for Incommensurable Objectives 482

Modeling with Fuzzy Sets 483

Non-MOLP Multiple Objective Models 483

MINICASE: SofSneez 483 MINICASE: Spacetrek 490

MINICASE: Budgeting in Blacksburg 494

Summary 499

Problems for Analysis 499

Practice Models 505

References and Additional Reading 507



15.

VISUAL AND MULTIATTRIBUTE CHOICE MODELS 508

Underlying Assumptions 509

Graphical Techniques: An Intuitive Description 509

Charts for Project Planning and Scheduling 511

Morphological Methods and Models 514

Matrix Modeling 520

Multiattribute Choice Models 522 A Multicriterion Decision Model 526

Critical Factors 526

Quantitative Factors 527

Qualitative Factors 527

The Evaluation Measure 528

A Project Selection Model 528

The Strategy Control Component 529

MINICASE: MIPS 529

MINICASE: T. N. Crumpets 533

Summary 537

Problems for Analysis 538

Practice Models 541

References and Additional Reading 542

EPILOGUE

MANAGEMENT SCIENCE & THE FUTURE 543

The Art of Constructing a Crystal Ball 543
Assumptions: The World of 2000 543
Deductions: The World of 2000 544
Implications: The World of 2000 545
References and Additional Reading 547

APPENDIXES

A. Standardized Normal Distribution 549

。1.4620 · 6440 · 6440 · 6460

B. Unit Normal Linear Loss Integral 550

GLOSSARY

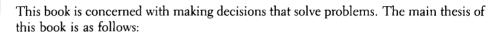
551

INDEX

557

1.

Problems, Models, Decisions, and Systems



The use of management science (MS) models can make us better decision makers and problem solvers.

Models help us to better understand problems and enable us to evaluate courses of action in making decisions. They reflect the structure of the system we use them to represent. A model is a paradigm—a description and explanation of the relationship of the parts of the problem to one another or of the problem to its environment.

Everyone uses models as a basis for making decisions. An oil firm executive gathers information in the form of printed data, listens to the opinions of others, and concludes that the firm must raise retail gasoline prices in accordance with increases in the price of crude. An economist reads the consumer price statistics and decides that more stringent controls on the money supply must be applied. An MBA student keeps close track of his or her course performance to determine how much effort he or she will require to achieve the desired grades. In each case, we formulate a mental model as a basis for making decisions. Even our interpersonal responses stem from models. Psychologists say that our mental model of ourselves—our self-image—strongly colors our personality.

Our mental concepts of a particular situation represent the model—either explicit or implicit—that we use to make decisions in both private and professional life. At times, that mental model is biased, fuzzy, incomplete, inaccurate, or just plain wrong. Obviously, the response or decision stemming from that mental model will probably be wrong also, and we must face the consequences of the misguided decision. The point is, we make all conscious decisions on the basis of models. The question, then, is not whether to use models but rather what kinds of models to use.

Consider a stockbroker poring over market projections on the screen of a personal computer. The broker's mental model of the stock market suggests that the market will continue to go up in the short run before dropping drastically. In light of this mental model, the stockbroker is advising clients to sell their holdings. If the stockbroker has many colleagues who share the same view of the market, the simultaneous advice those colleagues give to investors could actually cause the predicted downturn to occur. Thus, in this case, the mental model becomes self-fulfilling. Such are the hazards of forecasting models in the managerial sciences. Gloom-and-doom predictions may create the very factors responsible for drastic downward readjustments.

Clearly, models influence managerial behavior that weighs heavily upon the outcomes of the system itself. Self-image models, furthermore, tend to be consistently self-fulfilling.

This book focuses on management science (MS) models, and its premise is that such models are better decision aids than mental models alone. Actually, we use such models to influence, formalize, and concretize the mental models we use to make all decisions. An **MS model** is a model that encompasses quantitative, mathematical, or graphic forms. We distinguish it from the verbal models that make up much of the literature in business, economics, sociology, political science, and psychology.

We assert that MS models will enable us to make better decisions. We must address such questions as, What form do these models take? What data do we need? How do we formulate these models? How do we solve these models? The answers to these questions constitute most of the content of this book.

PROBLEMS AND DECISIONS

Problems arise whenever there is a *perceived* difference between what is desired and what is. In the language of the economist, wherever expectations differ substantially from realizations, a problem occurs. Problems serve as motivators for doing something. Since what we do must begin with a decision about what to do, problems ultimately lead to decisions (see Figure 1.1). The goal of decision making is mitigating or alleviating perceived problems.

In Figure 1.1a, a problem leads to a **decision** about that problem without the input from an MS model. The decision could be to do nothing for now. The decision will thereafter have an impact that will either diminish or exacerbate the problem. We will observe the effect on the problem, and this will lead to further decisions about the problem in question.

The plan and purpose of this book is to insert into the decision process the use of MS models (Figure 1.1b). We study the problem in the framework of its own system to enable contextual understanding of the problem. Thereafter we can develop an MS model of the "problem system." This is the essence of the so-called systems approach popularized in recent years by Churchman [2] and others. A good problem solver should try to develop the largest possible perspective of that problem. This is tantamount to understanding the problem within the context of its own system.

MODEL CLASSIFICATION

We can classify models in a variety of ways. For example, *purpose*, *perspective*, *degree* of abstraction, and content represent four classification criteria.

FIGURE 1.1 Relationships among models, problems, and decisions

45

