INTERNATIONAL EDITION

Management Science Eighth Edition



Taylor III



IMPORIANT COURSE SOFTWARE ON CO-ROM
Be sure the book you purchase includes the CO-ROM

Management Science

The Management Science Approach to Problem Solving 2

Observation 3 Definition of the Problem 3 Model Construction 3 Model Solution 4

■ Time Out: for Pioneers in Management Science 5

- Management Science Application: Management Science at Taco Bell 6

Implementation 7

Model Building: Break-Even Analysis 7 Components of Break-Even Analysis 7

Computing the Break-Even Point 8

Graphical Solution 9 Sensitivity Analysis 10

Computer Solution 12

Excel Spreadsheets 13

The Excel QM Macro for Spreadsheets 14

QM for Windows 15

Management Science Modeling Techniques 16 Linear Mathematical Programming Techniques 16

Probabilistic Techniques 17

Network Techniques 17

Other Techniques 18

Business Usage of Management Science Techniques 18

■ Management Science Application: Management Science at Federal Express 19

Management Science Models in Decision Support Systems 20

 Management Science Application: A Decision Support System for Aluminum Can Production at Coors 22

Summary 22 • References 23 • Problems 23 • Case Problems 26



Linear Programming: Model Formulation and Graphical Solution 28

Model Formulation 29

A Maximization Model Example

■ Time Out: for George B. Dantzig

Decision Variables 30

The Objective Function 30

Model Constraints 31 Graphical Solutions of Linear

Programming Models 32 Graphical Solution of a Maximization Model 32

 Management Science Application: Operational Cost Control at Kellogg's 33

The Optimal Solution Point 36

The Solution Values 38 Slack Variables 42

- Management Science Application: Estimating Food Nutrient Values at Minnesota's Nutrition Coordinating Center 44

Summary of the Graphical Solution Steps 44

A Minimization Model Example 45

Decision Variables 45

The Objective Function

Model Constraints 46

Graphical Solution of a Minimization Model 46

 Management Science Application: Chemical Production at Monsanto Surplus Variables 49

rregular Types of Linear Programming Problems 50	
Multiple Optimal Solutions 50	
An Infeasible Problem 51	
An Unbounded Problem 52	
Characteristics of Linear Programming Problems Properties of Linear Programming Models 53	53

Summary 54 • References 54 • Example Problem Solutions 54 • Problems 58 • Case Problems 66

Linear Programming: Computer Solution and Sensitivity Analysis 68

Computer Solution 69
Excel Spreadsheets 69
QM for Windows 73
Sensitivity Analysis 75

Changes in Objective Function Coefficients 75

 Management Science Application: Grape Juice Management at Welch's 77

Objective Function Coefficient Ranges with the Computer 80
Changes in Constraint Quantity Values 81
Constraint Quantity Values Range with the Computer 83
Other Forms of Sensitivity Analysis 84
Shadow Prices 86

Summary 87 • References 87 • Example Problem Solution 88 • Problems 90 • Case Problems 102

Linear Programming: Modeling Examples 104

A Product Mix Example 105
Decision Variables 106
The Objective Function 106
Model Constraints 106
Model Summary 106
Computer Solution with Excel 107
Computer Solution with QM for Windows 108
Solution Analysis 108

A Diet Example 109
Decision Variables 109
The Objective Function 110
Model Constraints 110
Model Summary 110
Computer Solution with Excel 110
Solution Analysis 111

An Investment Example 112

■ Management Science Application: The Evolution of the Diet Problem 113

Decision Variables 113
The Objective Function 113
Model Constraints 114
Model Summary 115
Computer Solution with Excel 115
Solution Analysis 116

 Management Science Application: A Linear Programming Model for Optimal Portfolio Selection at Prudential Securities, Inc. 118

A Marketing Example 118
Decision Variables 119
The Objective Function 119
Model Constraints 119
Model Summary 120
Computer Solution with Excel 120
Solution Analysis 121

A Transportation Example 121
Decision Variables 122
The Objective Function 123
Model Constraints 123
Model Summary 123
Computer Solution with Excel 124
Solution Analysis 124

A Blend Example 125
Decision Variables 125
The Objective Function 126
Model Constraints 126
Model Summary 127
Computer Solution with Excel 127
Solution Analysis 128

A Multiperiod Scheduling Example 129
Decision Variables 129

• Management Science Application: Gasoline Blending at Texaco 130

The Objective Function 130
Model Constraints 130
Model Summary 131
Computer Solution with Excel 131
Solution Analysis 132

A Data Envelopment Analysis Example 133

 Management Science Application: Analyzing Bank Branch Efficiency with DEA 134

Decision Variables 135
The Objective Function 135
Model Constraints 135
Model Summary 136
Computer Solution with Excel 136
Solution Analysis 136

Summary 137 • References 138 • Example Problem Solution 138 • Problems 140 • Case Problems 167

Integer Programming 171

Integer Programming Models 172 A Total Integer Model Example 172 A 0–1 Integer Model Example 173 A Mixed Integer Model Example 174

- Management Science Application: Allocating Operating Room Time at Toronto's Mount Sinai Hospital 175
 Integer Programming Graphical Solution 176
 Computer Solution of Integer Programming Problems with Excel and QM for Windows 178
 Solution of the 0-1 Model with Excel 178
- Time Out: for Ralph E. Gomory 179

 Solution of the 0–1 Model with QM for Windows 179
- Management Science Application: Minimizing Color Photographic Paper Waste at Kodak 181
 Solution of the Total Integer Model with Excel 181
 Solution of the Mixed Integer Model with Excel 182
 Solution of the Mixed Integer Model with QM for Windows 184

0–1 Integer Programming Modeling Examples 185 A Capital Budgeting Example 185

- Management Science Application: Optimal Assignment of Gymnasts to Events 185
 A Fixed Charge and Facility Location Example 187
 A Set Covering Example 190
- Management Science Application: Managing Prototype Vehicle Test Fleets at Ford 191

Summary 193 • References 193 • Example Problem Solution 194 • Problems 195 • Case Problems 206

Transportation, Transshipment, and Assignment Problems 211

The Transportation Model 212

- Time Out: for Frank L. Hitchcock and Tjalling C. Koopmans 214
- Management Science Application: Transporting Sand for Airport Construction Landfill 215

Computer Solution of a Transportation Problem 215

Computer Solution with Excel 215

Computer Solution with Excel QM 216

QM for Windows Solution 218

The Transshipment Model 219

Computer Solution with Excel 221

The Assignment Model 222

Computer Solution of the Assignment Problem 223
Computer Solution with Excel 223
Computer Solution with QM for Windows 225

 Management Science Application: Assigning Managers to Construction Projects 226

Summary 226 • References 227 • Example Problem Solution 227 • Problems 228 • Case Problems 251

7 Network Flow Models 256

Network Components 257

The Shortest Route Problem 258
The Shortest Route Solution Approach 259
Computer Solution of the Shortest Route Problem with QM for Windows 262
Computer Solution of the Shortest Route Problem with Excel 263

The Minimal Spanning Tree Problem 265

Management Science Application: Reducing Travel Costs at the Defense Contract Management Agency 266
 The Minimal Spanning Tree Solution Approach 267
 Computer Solution of the Minimal Spanning Tree Problem with QM for Windows 269

The Maximal Flow Problem 270
The Maximal Flow Solution Approach 270

- Time Out: for E. W. Dijkstra, L. R. Ford Jr., and D. R. Fulkerson 271
- Management Science Application: Improving Service for Yellow Freight System's Terminal Network 272
 Computer Solution of the Maximal Flow Problem with QM for Windows 273
 Computer Solution of the Maximal Flow Problem with Excel 274

Summary 276 • References 277 • Example Problem Solution 277 • Problems 279 • Case Problems 295

8 Project Management 301

The Elements of Project Management 302
The Project Team 302
Project Planning 303

 Time Oul: for Morgan R. Walker, James E. Kelley Jr., and D. G. Malcolm 304
 Project Control 304
 Project Networks 304

The Gantt Chart 304
The CPM/PERT Network 305

- Management Science Application: Project "Magic" at Disney Imagineering 306 Concurrent Activities 307
- Time Out: for Henry Gantt 307 The Critical Path 308 Activity Scheduling 310 Activity Slack 312

Probabilistic Activity Times 314 Probability Analysis of the Project Network 318

- Management Science Application: The Mars Pathfinder Project 320

CPM/PERT Analysis with QM for Windows 321

Activity-on-Node Networks and Microsoft Project 321 The AON Network Convention 321 Microsoft Project 322

Project Crashing and Time-Cost Trade-Off 324 Project Crashing with QM for Windows 328 The General Relationship of Time and Cost 328

 Management Science Application: Kodak's Advantix Advanced Photo System Project 329

Formulating the CPM/PERT Network as a Linear Programming Model 330

Solution of the CPM/PERT Linear Programming Model with Excel 331

Project Crashing with Linear Programming 333 Project Crashing with Excel 335

Summary 336 • References 337 • Example Problem Solution 337 • Problems 340 • Case Problems 354

357

Multicriteria Decision Making

Goal Programming 358 Model Formulation 358 Labor Goal 359 Profit Goal 360 Material Goal 360

Alternative Forms of Goal Constraints 361

Graphical Interpretation of Goal Programming 362 Computer Solution of Goal Programming Problems with QM for Windows and Excel 365

 Management Science Application: Developing Television Advertising Sales Plan at NBC 366 QM for Windows 366

Excel Spreadsheets 367

■ Time Out: for Abraham Charnes and William W. Cooper 369

The Analytical Hierarchy Process

 Management Science Application: Assigning MBA Students to Project Teams at the University of South Carolina 373

Pairwise Comparisons 374 Developing Preferences Within Criteria 375 Ranking the Criteria 376 Developing an Overall Ranking 377 AHP Consistency 378 AHP with Excel Spreadsheets 380

• Management Science Application: Selecting a Site for a New Ice Hockey Arena with AHP 381

Scoring Model 384 Scoring Model with Excel Solution 385

Summary 385 • References 386 • Example Problem Solution 386 • Problems 390 • Case Problems 414

Nonlinear Programming

417

Nonlinear Profit Analysis Constrained Optimization 421

Solution of Nonlinear Programming Problems with Excel 424

A Nonlinear Programming Model with Multiple Constraints 427

Nonlinear Model Examples 429 Facility Location 429 Investment Portfolio Selection 431

■ Management Science Application: Gas Production in Australia 432

Summary 434 • References 435 • Example Problem Solution 435 • Problems 435 • Case Problems 440

ir) Probability and Statistics 442

Types of Probability \ 443 Objective Probability 443 Subjective Probability 444

Fundamentals of Probability 445

- Management Science Application: Treasure Hunting with

Probability and Statistics 447 Statistical Independence and Dependence 449

Independent Events 449 Probability Trees 450 The Binomial Distribution 450

Dependent Events 453

Expected Value 456

Bayesian Analysis

 Management Science Application: A Probability Model for Analyzing Coast Guard Patrol Effectiveness 458

The Normal Distribution 458
Sample Mean and Variance 463
The Chi-Square Test for Normality 465
Statistical Analysis with Excel 468

Summary 470 • References 470 • Example Problem Solution 470 • Problems 472 • Case Problem 479

Decision Analysis 480

Components of Decision Making 481

Decision Making without Probabilities 482

Decision-Making Criteria 482

The Maximax Criterion 482

 Management Science Application: Decision Analysis at DuPont 483

The Maximin Criterion 483
The Minimax Regret Criterion 484
The Hurwicz Criterion 485
The Equal Likelihood Criterion 486
Summary of Criteria Results 486
Solution of Decision-Making Problems without Probabilities with QM for Windows 487

Decision Making with Probabilities 488

Expected Value 488

Expected Opportunity Loss 489

Solution of Expected Value Problems with QM for Windows 490

Solution of Expected Value Problems with Excel and Excel QM 490

Expected Value of Perfect Information 491

Decision Trees 493

Decision Trees with QM for Windows 495

Decision Trees with Excel and TreePlan 495

Management Science Application: Evaluating Electric Generator Maintenance Schedules with Decision Tree Analysis 498
 Sequential Decision Trees 498
 Sequential Decision Tree Analysis with QM for Windows 501
 Sequential Decision Tree Analysis with Excel and TreePlan 502
 Decision Analysis with Additional Information 502

- Management Science Application: Decision Analysis in the Electric Power Industry 503

 Decision Trees with Posterior Probabilities 504
- Management Science Application: Discount Fare Allocation at American Airlines 506
 Computing Posterior Probabilities with Tables 508
 Computing Posterior Probabilities with Excel 508

The Expected Value of Sample Information 509

 Management Science Application: Scheduling Refueling at the Indian Point 3 Nuclear Power Plant 510
 Utility 510

Summary 512 • References 512 • Example Problem Solution 512 • Problems 516 • Case Problems 533

Queuing Analysis 537

Elements of Waiting Line Analysis 538
The Single-Server Waiting Line System 539
The Queue Discipline 539

■ Time Oul: for Agner Krarup Erlang 540
The Calling Population 540

The Arrival Rate 540

The Service Rate 540

The Single-Server Model 541

The Effect of Operating Characteristics on Managerial

The Effect of Operating Characteristics on Managerial Decisions 544

Computer Solution of the Single-Server Model with Excel and Excel QM 546

Computer Solution of the Single-Server Model with QM for Windows 548

Undefined and Constant Service Times 548

■ Management Science Application: Reducing Arrest-to-Arraignment Times in New York City 550

Computer Solution of the Constant Service Time Model wi

Computer Solution of the Constant Service Time Model with Excel 551

Computer Solution of the Undefined and Constant Service Time Models with QM for Windows 552

Finite Queue Length 552

■ Management Science Application: Providing Optimal Telephone Order Service at L. L. Bean 554
Computer Solution of the Finite Queue Model with Excel 554
Computer Solution of the Finite Queue Model with QM for Windows 555

Finite Calling Population 555

Computer Solution of the Finite Calling Population Model with Excel and Excel QM 557

Computer Solution of the Finite Calling Population Model with QM for Windows 558

The Multiple-Server Waiting Line 558

Computer Solution of the Multiple-Server Model with Excel and Excel QM 562

Computer Solution of the Multiple-Server Model with QM for Windows 563

Additional Types of Queuing Systems 563

Summary 564 • References 565 • Example Problem Solution 565 • Problems 566 • Case Problems 574



Simulation 576

The Monte Carlo Process 577 The Use of Random Numbers 577

- Management Science Application: Improving the Red Cross Blood Donation Process Using Simulation 581
- Time Out: for John Von Neumann 582

Computer Simulation with Excel Spreadsheets 583 Decision Making with Simulation 586

Simulation of a Queuing System 588 Computer Simulation of the Queuing Example with Excel 591

 Management Science Application: Simulating the Israeli **Army Recruitment Process**

Continuous Probability Distributions 593 Simulation of a Machine Breakdown and Maintenance System 594

Computer Simulation of the Machine Breakdown Example Using Excel 596

Statistical Analysis of Simulation Results 598

Crystal Ball 600

Simulation of a Profit Analysis Model 600

Verification of the Simulation Model 608

Areas of Simulation Application

Queuing 609

Inventory Control 609

Production and Manufacturing

Finance 609

Marketing 609

Public Service Operations 609

Environmental and Resource Analysis 609

• Management Science Application: Simulating a 10-km Race in Boulder, Colorado 610

Summary 610 • References 611 • Example Problem Solution 611 • Problems 613 • Case Problems 628



Forecasting

Forecasting Components 632 Forecasting Methods 633 Time Series Methods 634 Moving Average 634 Weighted Moving Average 637

• Management Science Application: Product Forecasting at Nabisco 638

Exponential Smoothing 639

• Management Science Application: Forecasting Customer Demand at Taco Bell 639

Adjusted Exponential Smoothing 642 Linear Tread Line 644

- Management Science Application: Forecasting Demand for Discount Fares at American Airlines 644 Seasonal Adjustments 646
- Management Science Application: Forecasting Service Calls at Federal Express 648

Forecast Accuracy 648 Mean Absolute Deviation 649 Cumulative Error 650

- Management Science Application: Demand Forecasting at National Car Rental 652

Time Series Forecasting Using Excel 653 Computing the Exponential Smoothing Forecast with Excel QM 655

Time Series Forecasting Using QM for Windows 655

Regression Methods 656

Linear Regression

Correlation 658

 Management Science Application: Competing with Accurate Daily Demand Forecasts at Vermont Gas Systems 660

Regression Analysis with Excel 660 Regression Analysis with QM for Windows 664 Multiple Regression with Excel 665

Summary 667 • References 667 • Example Problem Solutions 668 • Problems 670 • Case Problems 689



16 Inventory Management 691

Elements of Inventory Management 692 The Role of Inventory 692 Demand 693 Inventory Costs 693 **Inventory Control Systems** 694

Continuous Inventory Systems 694 Periodic Inventory Systems 695

■ Time Out: for Ford Harris 696

Economic Order Quantity Models 696

The Basic EOQ Model

Carrying Cost 697

Ordering Cost 699

Total Inventory Cost 699 EOQ Analysis over Time 701

The EOQ Model with Noninstantaneous Receipt 702

The EOQ Model with Shortages 705

■ Management Science Application: Online Inventory Management at IBM 708

EOQ Analysis with QM for Windows 709

EOQ Analysis with Excel and Excel QM 709

Ouantity Discounts 710

Quantity Discounts with Constant Carrying Costs 711

Quantity Discounts with Constant Carrying Costs

as a Percentage of Price 712

Quantity Discount Model Solution with QM for Windows 714

Reorder Point 714

Safety Stocks 715

Determining Safety Stocks Using Service Levels 71
Reorder Point with Variable Demand 716
Determining the Reorder Point with Excel 717
Reorder Point with Variable Lead Time 718
Reorder Point with Variable Demand and Lead Time 718

 Management Science Application: Establishing Inventory Safety Stocks at Kellogg's 719

Order Quantity for a Periodic Inventory System 720
Order Quantity with Variable Demand 720
Determining the Order Quantity for the Fixed-Period Model
with Excel 721

Summary 722 • References 722 • Example Problem Solutions 722 • Problems 724 • Case Problems 731

Appendix A Normal Table 733

Appendix B

Setting Up and Editing a Spreadsheet 735

Titles and Headings 735

Borders 735

Column Centering 736

Deleting and Inserting Rows and Columns 736

Decimal Places 736

Appendix C

The Poisson and Exponential Distributions 739

The Poisson Distribution 739

The Exponential Distribution 740

Solutions to Selected Odd-Numbered Problems 741

Glossary 749

Index 755

Photo Credits 763

CD-ROM Modules

Module A: The Simplex Solution Method A-1

Module B: Transportation and Assignment Solution
Methods B-1

Module C: Integer Programming: The Branch and Bound Method C-1

Module D: Nonlinear Programming Solution Techniques
D-1

Module E: Game Theory E-1

Module F: Markov Analysis F-1