H.A. Eiselt • C.-L. Sandblom

Operations Research

A Model-Based Approach



CONTENTS

Preface

.

1. Introduction to Operations Research	1
1.1 The Nature and History of Operations Research	1
1.2 The Main Elements of Operations Research	4
1.3 The Modeling Process	. 9
2. Linear Programming	13
2.1 Introduction to Linear Programming	13
2.2 Applications of Linear Programming	18
2.2.1 Production Planning	18
2.2.2 Diet Problems	20
2.2.3 Allocation Problems	28
2.2.4 Employee Scheduling	32
2.2.5 Dynamic Production-Inventory Models	35
2.2.6 Blending Problems	39
2.2.7 Transportation and Assignment Problems	43
Exercises	50
2.3 Graphical Representation and Solution	60
2.3.1 The Graphical Solution Method	60
2.3.2 Special Cases of Linear Programming Problems	70
Exercises	76
2.4 Postoptimality Analyses	78
2.4.1 Graphical Sensitivity Analyses	78
2.4.2 Economic Analysis of an Optimal Solution	92
Exercises	100
2.5 Duality	105
Exercises	112

Contents

3. Multiobjective Programming 13.1 Vector Optimization13.2 Solution Approaches to Vector Optimization Problems11	15 16 21 24
3.1 Vector Optimization 1 3.2 Solution Approaches to Vector Optimization Problems 1	16 21 24
3.2 Solution Approaches to Vector Optimization Problems	21 24
	24
3.3 Goal Programming	20
Exercises	29
4. Integer Programming	35
4.1 Definitions and Basic Concepts	35
4.2 Applications of Integer Programming	40
4.2.1 Cutting Stock Problems	42
4.2.2 Diet Problems Revisited	46
4.2.3 Land Use 1	48
4.2.4 Modeling Fixed Charges 1	50
4.2.5 Workload Balancing	52
4.3 Solution Methods for Integer Programming Problems	54
4.3.1 Cutting Plane Methods 1	54
4.3.2 Branch-and-Bound Methods	55
4.3.3 Heuristic Methods	62
Exercises	65
5. Network Models	77
5.1 Definitions and Conventions 1	77
5.2 Network Flow Problems 1	79
5.3 Shortest Path Problems 1	89
5.4 Spanning Tree Problems	98
5.5 Routing Problems 2	:00
Exercises 2	:05
6. Location Models 2	217
6.1 The Major Elements of Location Problems 2	217
6.2 Covering Problems 2	220
6.2.1 The Location Set Covering Problem 2	21
6.2.2 The Maximal Covering Location Problem 2	27
6.3 Center Problems 2	230
6.3.1 1-Center Problems 2	231
6.3.2 <i>p</i> -Center Problems 2	233
6.4 Median Problems 2	235
6.4.1 Minisum Problems in the Plane 2	235
6.4.2 Minisum Problems in Networks 2	240
6.5 Other Location Problems 2	244
Exercises 2	:47
7. Project Networks 2	257
7.1 The Critical Path Method 2	258
7.2 Project Acceleration 2	266

х

•

•

Contents	xi
7.3 Project Planning with Resources	272
7.4 The PERT Method	275
Exercises	280
8. Machine Scheduling	287
8.1 Basic Concepts of Machine Scheduling	288
8.2 Single Machine Scheduling	290
8.3 Parallel Machine Scheduling	294
8.4 Dedicated Machine Scheduling	297
Exercises	301
9. Decision Analysis	305
9.1 Introduction to Decision Analysis	305
9.2 Visualizations of Decision Problems	307
9.3 Decision Rules Under Uncertainty and Risk	310
9.4 Sensitivity Analyses	316
9.5 Decision Trees and the Value of Information	319
9.6 Utility Theory	327
Exercises	328
10. Inventory Models	339
10.1 Basic Concepts in Inventory Planning	339
10.2 The Economic Order Quantity (EOQ) Model	343
10.3 The Economic Order Quantity with Positive Lead Time	346
10.4 The Economic Order Quantity with Backorders	349
10.5 The Economic Order Quantity with Quantity Discounts	352
10.6 The Production Lot Size Model	355
10.7 The Economic Order Quantity with Stochastic	
Lead Time Demand	357
10.7.1 A Model that Optimizes the Reorder Point	359
10.7.2 A Stochastic Model with Simultaneous Computation	200
of Order Quantity and Reorder Point	300
10.8 Extensions of the Basic Inventory Models	262
Exercises	303
11. Stochastic Processes and Markov Chains	367
11.1 Basic Ideas and Concepts	367
11.2 Steady-State Solutions	372
11.3 Decision Making with Markov Chains	373
Exercises	376
12. Waiting Line Models	379
12.1 Basic Queuing Models	380
12.2 Optimization in Queuing	388
Exercises	392

Contents

13. Simulation	395
13.1 Introduction to Simulation	395
13.2 Random Numbers and their Generation	397
13.3 Examples of Simulations	402
13.3.1 Simulation of a Waiting Line System	402
13.3.2 Simulation of an Inventory System	405
Exercises	410
Appendiese	
Appendices	
A. Heuristic Algorithms	417
B. Vectors and Matrices	427
C. Systems of Simultaneous Linear Equations	429
D. Probability and Statistics	433
References	441
Subject Index	443

15