

# Contents

Preface . . . . .	vii
Acknowledgements . . . . .	viii
<b>Book Overview</b>	<b>1</b>
<b>I METHODOLOGY AND ANALYSIS OF FACILITY LOCATION</b>	<b>7</b>
<b>1 Estimating Distances</b>	<b>9</b>
<i>Jack Brimberg and Robert F. Love</i>	
1.1 Introduction . . . . .	9
1.2 Norms as Distance Estimating Functions . . . . .	10
1.3 The $\ell_p$ Norm . . . . .	15
1.4 Conclusions . . . . .	31
<b>2 Replacing Discrete Demand with Continuous Demand</b>	<b>33</b>
<i>Zvi Drezner</i>	
2.1 Introduction . . . . .	33
2.2 Formulation and Analysis . . . . .	34
2.3 Evaluating a Double Integral . . . . .	35
2.4 Analysis of the Example Problem . . . . .	37
2.5 The Distance Correction Approach . . . . .	41
2.6 Conclusions . . . . .	42
<b>3 Global Optimization in Location</b>	<b>43</b>
<i>Pierre Hansen, Brigitte Jaumard, and Hoang Tuy</i>	
3.1 Introduction . . . . .	43
3.2 Branch-and-bound Methods . . . . .	45
3.3 Lipschitz Optimization . . . . .	50
3.4 Outer Approximation . . . . .	52
3.5 Polyhedral Annexation . . . . .	57
3.6 Decomposition Methods . . . . .	62
3.7 Linearization Methods . . . . .	63
3.8 Specialized Methods . . . . .	65
3.9 Conclusions . . . . .	67

<b>4</b>	<b>Inferred Ideal Weights for Multiple Facilities</b>	<b>69</b>
	<i>Morton E. O'Kelly</i>	
4.1	Introduction . . . . .	69
4.2	Information Minimizing Model . . . . .	70
4.3	Extensions to Multiple Facilities . . . . .	77
4.4	Conclusions . . . . .	88
<b>5</b>	<b>Conjugate Duality in Facility Location</b>	<b>89</b>
	<i>Carlton H. Scott, Thomas R. Jefferson, and Soheila Jorjani</i>	
5.1	Introduction . . . . .	89
5.2	Conjugate Duality Theory . . . . .	90
5.3	The Minisum Model . . . . .	93
5.4	The Minimax Model . . . . .	99
<b>6</b>	<b>Using Voronoi Diagrams</b>	<b>103</b>
	<i>Atsuo Suzuki and Atsuyuki Okabe</i>	
6.1	Introduction . . . . .	103
6.2	The Voronoi Diagram . . . . .	104
6.3	The Continuous $p$ -median Problem . . . . .	105
6.4	Continuous $p$ -center Problems . . . . .	108
6.5	The Time-Space $p$ -Median Problem . . . . .	111
6.6	Mobile Facility Location Problem (Constrained $p$ -median) . . . . .	114
6.7	Other Continuous Location Problems . . . . .	116
6.8	Conclusions . . . . .	118
<b>II</b>	<b>VARIOUS OBJECTIVES IN FACILITY LOCATION</b>	<b>119</b>
<b>7</b>	<b>Location with Market Externalities</b>	<b>121</b>
	<i>Margaret L. Brandeau, Samuel S. Chiu, Shiv Kumar, and Thomas A. Grossman, Jr.</i>	
7.1	Introduction . . . . .	121
7.2	Notation and Assumptions . . . . .	124
7.3	Analysis of User-Choice Equilibrium . . . . .	126
7.4	Facility Location with Market Externalities . . . . .	130
7.5	Resource Allocation with Market Externalities . . . . .	144
7.6	Future Research and Conclusions . . . . .	150
<b>8</b>	<b>Objectives in Location Problems</b>	<b>151</b>
	<i>H.A. Eiselt and Gilbert Laporte</i>	
8.1	Introduction . . . . .	151
8.2	Elements of Location Models . . . . .	152
8.3	Pull Objectives . . . . .	156
8.4	Push Objectives . . . . .	165

8.5	Balancing Objectives . . . . .	169
8.6	Conclusions . . . . .	179
8.7	Glossary . . . . .	179
<b>9</b>	<b>Distribution System Design</b>	<b>181</b>
	<i>Arthur M. Geoffrion, James G. Morris, and Scott T. Webster</i>	
9.1	Introduction . . . . .	181
9.2	A Case Study . . . . .	182
9.3	Diagnostic Tools . . . . .	190
9.4	Algebraic Language Tools . . . . .	192
9.5	Conclusions . . . . .	195
9.6	Annotated Bibliography . . . . .	196
<b>10</b>	<b>Siting Emergency Services</b>	<b>199</b>
	<i>Vladimir Marianov and Charles ReVelle</i>	
10.1	Introduction - What are the Important Issues? . . . . .	199
10.2	Methods Based on Deterministic Optimization Models . . . . .	204
10.3	Deterministic Models Addressing Congestion . . . . .	210
10.4	Methods Based on Probabilistic Optimization Models . . . . .	213
10.5	Descriptive Models and Heuristic Solution Procedures . . . . .	218
10.6	Conclusions . . . . .	222
<b>11</b>	<b>Continuous Location Problems</b>	<b>225</b>
	<i>Frank Plastria</i>	
11.1	Continuous Location . . . . .	225
11.2	Distance . . . . .	229
11.3	Dominance, Efficiency and Voting . . . . .	235
11.4	Single Facility Location Problems . . . . .	239
11.5	Single Facility Location-Allocation Problems . . . . .	251
11.6	Multifacility Location Problems . . . . .	253
11.7	Multifacility Location-Allocation Problems . . . . .	257
11.8	Other Related Problems . . . . .	260
<b>12</b>	<b>Global Manufacturing Strategy</b>	<b>263</b>
	<i>Vedat Verter and M. Cemal Dincer</i>	
12.1	Introduction . . . . .	263
12.2	Global Manufacturing Strategy Planning Process . . . . .	266
12.3	The Production-Distribution System Design Problem . . . . .	270
12.4	Designing International Production-Distribution Systems . . . . .	276
12.5	Concluding Comments . . . . .	281

# III COMPETITIVE FACILITY LOCATION 283

## 13 Competitive Facility Location in the Plane 285

*Tammy Drezner*

13.1 Introduction . . . . .	285
13.2 The Deterministic Utility Model . . . . .	289
13.3 The Random Utility Model . . . . .	290
13.4 Gravity Models . . . . .	292
13.5 Computational Results . . . . .	295
13.6 Conclusions . . . . .	298

## 14 Multifacility Retail Networks 301

*Avijit Ghosh, Sara McLafferty, and C. Samuel Craig*

14.1 Introduction . . . . .	301
14.2 Location-Allocation Models . . . . .	302
14.3 The Components of Retail Location-Allocation Models . . .	304
14.4 Five Types of Location-Allocation Models . . . . .	306
14.5 Applying Covering Models for Service Center Location . . .	316
14.6 Extension to Basic Models . . . . .	325
14.7 Conclusions . . . . .	329

## 15 Economic Models of Firm Location 331

*Dominique Peeters and Jacques-François Thisse*

15.1 Introduction . . . . .	331
15.2 Spatial Pricing Policies . . . . .	334
15.3 Finding the Optimal Price(s) . . . . .	340
15.4 The Price-Continuous Facility Location Problem . . . . .	350
15.5 The Price-Discrete Facility Location Problem . . . . .	357
15.6 Conclusions . . . . .	366

## 16 Competitive Location in Discrete Space 367

*Daniel Serra and Charles ReVelle*

16.1 Introduction . . . . .	367
16.2 Discrete Competitive Location Models: An Overview . . . .	368
16.3 A Review of The Maximum Capture Problem . . . . .	372
16.4 Extensions of the Maximum Capture Problem . . . . .	375
16.5 Extensions of the Pre-emptive Capture Problem . . . . .	380
16.6 Conclusions . . . . .	384

# IV ROUTING AND LOCATION 387

## 17 Flow-Interception Problems 389

*Oded Berman, M. John Hodgson, and Dmitry Krass*

17.1 Introduction . . . . .	389
17.2 Deterministic Flow Interception Problems . . . . .	390

17.3 Probabilistic Flow Interception Problems . . . . .	406
17.4 Future Research . . . . .	425
<b>18 Location-Routing Problems with Uncertainty</b>	<b>427</b>
<i>Oded Berman, Patrick Jaillet, and David Simchi-Levi</i>	
18.1 Introduction . . . . .	427
18.2 The Traveling Salesman Location Problem . . . . .	432
18.3 The Probabilistic Traveling Salesman Location Problem . .	441
18.4 Applications to Systems Design and Strategic Planning . .	451
18.5 A Different Class of Stochastic Facility Location Problems .	452
<b>19 Location, Routing and the Environment</b>	<b>453</b>
<i>Brian Boffey and John Karkazis</i>	
19.1 Introduction . . . . .	453
19.2 The Mechanism of Airborne Pollution Spread . . . . .	454
19.3 Relevant Features of Bicriterion Problems . . . . .	458
19.4 Location of Obnoxious Facilities . . . . .	461
19.5 Routing of Obnoxious Vehicles . . . . .	463
19.6 Future Directions . . . . .	465
<b>20 Hazardous Materials Logistics</b>	<b>467</b>
<i>Erhan Erkut and Vedat Verter</i>	
20.1 Introduction . . . . .	467
20.2 Risk Assessment . . . . .	470
20.3 Equity . . . . .	478
20.4 Cost Aspects . . . . .	482
20.5 Planning Potentially Hazardous Facilities . . . . .	483
20.6 Hazardous Materials Transport Planning . . . . .	490
20.7 Integrated Models . . . . .	497
20.8 Conclusions and Suggestions . . . . .	500
<b>References</b>	<b>507</b>