 CONTENTS

Introduction to the Series v

Chapter 1
Introduction
DAVID A. HENSHER and KENNETH J. BUTTON 1
1. Introduction 1
2. Transport modelling 2
3. What is a good model? 3
4. Where is transport modelling moving? 5
5. The changing policy agenda 7
6. The Handbook 9

Chapter 2
History of Demand Modelling
JOHN BATES 11
1. Introduction 11
2. Supply and demand 12
3. Aspects of demand 14
4. The four-stage model 17
  4.1. Assignment 18
  4.2. Concluding remarks 20
5. Models of trip production 20
  5.1. Car ownership 23
  5.2. Models of trip attraction 25
6. Models of distribution or destination choice 26
  6.1. Forecasting the future distribution 29
7. Models of mode choice 29
8. Overall model structure 31
References 32

Chapter 3
The Four-step Model
MICHAEL G. MCNALLY 35
1. Introduction 35
2. Transportation systems analysis 36
3. Problems, study areas, models, and data
   3.1. Study area definition
   3.2. Models
   3.3. Data
   3.4. A sample problem
4. Trip generation
   4.1. Process
   4.2. A sample household-trip-production model
   4.3. A sample zonal-atraction model
   4.4. Application to the base population
   4.5. Time of day
5. Trip distribution
   5.1. Process
   5.2. Travel impedance and skim trees
   5.3. A sample gravity model
   5.4. Adjustments
6. Mode choice
7. Route choice
   7.1. Process
   7.2. A sample assignment of vehicle trip tables to the highway network
8. Summary
References
### Chapter 5

**Flexible Model Structures for Discrete Choice Analysis**
CHANDRA R. BHAT  
1. Introduction  
2. Heteroscedastic models  
   2.1. Model formulations  
   2.2. HEV model structure  
   2.3. HEV model estimation  
   2.4. Transport applications  
3. Flexible structure models  
   3.1. Model formulations  
   3.2. MMNL structure  
   3.3. MMNL estimation methodology  
   3.4. Transport applications  
4. Conclusions  
References

### Chapter 6

**Duration Modeling**
CHANDRA R. BHAT  
1. Introduction  
2. The hazard function and its distribution  
   2.1. Parametric hazard  
   2.2. Nonparametric hazard  
3. Effect of external covariates  
   3.1. The proportional hazard form  
   3.2. The accelerated lifetime form  
   3.3. General form  
4. Unobserved heterogeneity  
5. Model estimation  
   5.1. Parametric hazard distribution  
   5.2. Nonparametric hazard distribution  
6. Miscellaneous other topics  
   6.1. Left censoring  
   6.2. Time-varying covariates  
   6.3. Multiple spells  
   6.4. Multiple-duration processes  
References
Contents

1. Introduction . 145
2. Model structure 147
3. The land-use model 149
  3.1. The bid-choice location framework 150
  3.2. The stochastic location model 153
  3.3. The land-use model 154
4. Measuring access 155
  4.1. Application example 157
5. Transport impacts on land use 160
6. Lessons for economic appraisal 161
7. Concluding remarks 162
References 163

Chapter 10

Travel Networks
LUIS G. WILLUMSEN 165
1. Introduction 165
  1.1. Flows and capacity 167
2. Notation 168
3. Assignment methods 169
  3.1. Route choice 170
  3.2. Steps in traffic assignment 171
  3.3. Tree building 171
  3.4. All-or-nothing assignment 173
  3.5. Stochastic methods 173
  3.6. Simulation-based methods 173
4. Congested assignment 174
  4.1. Wardrop's equilibrium 174
  4.2. A mathematical programming approach 176
  4.3. Solution methods 177
5. Limitations of classic methods 178
6. Generalized networks 179
  6.1. Common passenger services 179
  6.2. Freight 180
References 180

Chapter 11

Analytical Dynamic Traffic Assignment Models
TERRY L. FRIESZ and DAVID BERNSTEIN 181
1. Introduction 181
2. What is dynamic traffic assignment? 182
3. Dynamic network loading and dynamic traffic assignment 183
   3.1. Notation 183
4. Dynamics based on arc exit-flow functions 183
5. Dynamics with controlled entrance and exit flows 185
6. Cell transmission dynamics 187
7. Dynamics based on arc exit-time functions 188
8. Dynamic user equilibrium 191
9. Tatonnement and projective dynamics 193
References 194

Chapter 12
Transport Demand Elasticities
TAE HOON OUM and W. G. WATERS II 197
1. Concepts and interpretation of demand elasticities 197
   1.1. Ordinary and compensated elasticities 197
   1.2. Other elasticity concepts 198
   1.3. Mode-choice elasticities 201
   1.4. Disaggregate discrete-choice models 202
   1.5. Linkages between concepts of elasticities 203
2. Estimates of price elasticities 204
3. Some guidelines and pitfalls in estimating transport demand elasticities 206
   3.1. The importance of market-specific demand studies 206
   3.2. Types of transport demand elasticity studies 206
   3.3. Specification of demand functions 207
   3.4. Interpretation of elasticities 208
4. Concluding remarks 209
References 209

Chapter 13
Closed-form Discrete-choice Models
FRANK S. KOPPELMAN and VANEET SETHI 211
1. Introduction 211
2. Multinomial logit model 212
   2.1. Independence of errors across alternatives 213
   2.2. Equality of error variance across cases 213
3. Relaxation of the independence of errors across alternatives 214
   3.1. The nested logit model 214
   3.2. Generalized extreme value models 216
   3.3. Universal (mother) logit models 221
   3.4. Overview of models that relax the independence of errors over alternatives 222
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Survey and sampling strategies</td>
<td>229</td>
</tr>
<tr>
<td></td>
<td>Peter R. Stopher</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Introduction</td>
<td>229</td>
</tr>
<tr>
<td></td>
<td>2. Survey methods</td>
<td>231</td>
</tr>
<tr>
<td></td>
<td>2.1. Household travel surveys</td>
<td>232</td>
</tr>
<tr>
<td></td>
<td>2.2. Other non-household-based surveys</td>
<td>235</td>
</tr>
<tr>
<td></td>
<td>3. Sampling strategies</td>
<td>239</td>
</tr>
<tr>
<td></td>
<td>3.1. Sampling frames</td>
<td>240</td>
</tr>
<tr>
<td></td>
<td>3.2. Error and bias</td>
<td>240</td>
</tr>
<tr>
<td></td>
<td>3.3. Sampling methods</td>
<td>241</td>
</tr>
<tr>
<td></td>
<td>4. The future</td>
<td>249</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>250</td>
</tr>
<tr>
<td>15</td>
<td>Geographical Information Systems for Transport</td>
<td>253</td>
</tr>
<tr>
<td></td>
<td>KENNETH J. DUEKER and TU TON</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Introduction</td>
<td>253</td>
</tr>
<tr>
<td></td>
<td>2. GIS basics</td>
<td>254</td>
</tr>
<tr>
<td></td>
<td>2.1. Definition of GIS</td>
<td>254</td>
</tr>
<tr>
<td></td>
<td>2.2. Four key functions of GIS</td>
<td>255</td>
</tr>
<tr>
<td></td>
<td>2.3. Special requirements of GIS for transport applications</td>
<td>257</td>
</tr>
<tr>
<td></td>
<td>3. A framework for GIS-T</td>
<td>258</td>
</tr>
<tr>
<td></td>
<td>4. Two illustrative examples of GIS-T</td>
<td>261</td>
</tr>
<tr>
<td></td>
<td>4.1. Evolution of GIS to support comprehensive urban land use and</td>
<td>261</td>
</tr>
<tr>
<td></td>
<td>transportation planning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.2. The development of digital road map databases for vehicle</td>
<td>265</td>
</tr>
<tr>
<td></td>
<td>navigation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Conclusion</td>
<td>268</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>268</td>
</tr>
<tr>
<td>16</td>
<td>Definition of Movement and Activity for Transport Modeling</td>
<td>271</td>
</tr>
<tr>
<td></td>
<td>KLAUS W. AXHAUSEN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Introduction</td>
<td>271</td>
</tr>
<tr>
<td></td>
<td>2. Types of data</td>
<td>272</td>
</tr>
<tr>
<td></td>
<td>3. Defining movement and activity</td>
<td>273</td>
</tr>
<tr>
<td></td>
<td>4. Typical items and problems of aggregation</td>
<td>276</td>
</tr>
</tbody>
</table>
5. Defining the survey object
6. Translating the definitions into surveys
7. Freight and commercial traffic
8. Summary
References

Chapter 17
Environmental Valuation
RHONDA DANIELS and VIC ADAMOWICZ

1. Introduction
   1.1. Values
   1.2. Range of environmental impacts of transport
   1.3. Modeling environmental values: the linkage to biophysical models
   1.4. Models: transport and environmental links
2. Modeling approaches
   2.1. Weak behavioral linkage methods
   2.2. Revealed-preference approaches
   2.3. Stated-preference approaches
   2.4. Combining data sources
3. Case study: recreation site choice model
4. Valuation issues and future developments
   4.1. Valuation issues
   4.2. Future developments
5. Summary
References

Chapter 18
Allocation and Valuation of Travel-time Savings
SERGIO R. JARA-DIAZ

1. Introduction
2. Time allocation theory and the subjective value of time
3. Discrete travel choice and the value of time
4. Towards social values
5. Synthesis and conclusion
Appendix
References

Chapter 19
Cost Functions in Transport
ERIC PELS and PIET RIETVELD

1. Introduction
2. Estimation of cost functions
3.4. The usefulness of opportunities to the entering drivers 378
3.5. The relative priority of traffic at the junction 379
3.6. The capacity of simple merges with absolute priority 379
3.7. The capacity of a limited priority merge and a roundabout entry 380
3.8. The estimation of delays at simple merges with absolute priority 381
3.9. Estimation of delay using M/M/1 queuing theory 382
3.10. Delays under oversaturated conditions 383
3.11. Queue lengths at simple merges 384
3.12. Analysis of junctions with a number of streams 385
3.13. Queueing across a median 386

4. Signalized junctions 386
   4.1. Effective red and green periods 386
   4.2. The definition of delays at a signalized junction 387
   4.3. Delay models for undersaturated conditions 388
   4.4. Time-dependent delay estimates 389
   4.5. Modeling of turns through oncoming traffic at signalized junctions 390

References 390

Chapter 23

Trip Timing
HANI S. MAHAMASSANI 393
1. Introduction 393
2. Trip timing for the work commute under equilibrium conditions 395
3. Prediction of within-day equilibrium departure patterns 397
4. Day-to-day dynamics 398
   4.1. Daily variability of trip-timing decisions of commuters in actual systems 399
   4.2. Behavioral mechanisms and decision-process models 401
   4.3. Day-to-day forecasting frameworks 403
5. Concluding comments 404
References 405

Chapter 24

Modeling Parking
WILLIAM YOUNG 409
1. Introduction 409
2. Hierarchy of models 409
3. Model types 412
   3.1. Parking-design models 412
   3.2. Parking-allocation models 414
3.3. Parking-search models 416
3.4. Parking-choice models 417
3.5. Parking interaction models 419
4. Conclusions 419
References 420

Chapter 25
National Models
ANDREW DALY 421
1. Introduction 421
2. European national models 1975–1995 423
   2.1. The regional highways traffic model, England 423
   2.2. The Netherlands national model 424
   2.3. Norwegian national model 426
   2.4. Italian national model 427
   2.5. Danish and Swedish national models 428
   2.6. Other European national models 429
   2.7. Proposed model of Great Britain 429
3. Model design: Similarities and differences 430
4. Discussion and conclusions 431
References 432

Chapter 26
An Introduction to the Valuation of Travel-time Savings and Losses
HUGH F. GUNN 433
1. Introduction 433
2. Conceptual models of time–cost trading 434
   2.1. A simple behavioral model 434
   2.2. More elaborate models of rational behavior 435
3. Experimental data: Situations and evidence of preference 437
   3.1. Situations 438
   3.2. Indications of relative attractiveness 439
4. The history of VTTS measurement 439
   4.1. A pencil-and-paper approach 440
   4.2. Probabilistic choice models 442
   4.3. Regression approaches with transfer-price data 442
5. Current findings 443
   5.1. Personal travel 443
   5.2. Business travel and freight 444
6. Recent results and conclusions 445
References 447
Chapter 27
Can Telecommunications Help Solve Transportation Problems?
ILAN SALOMON

1. Introduction
   1.1. Background
   1.2. ICT applications
2. Do ICT affect the demand for travel? The main issues
   2.1. A typology of interactions
   2.2. Uncertainty about technology and behavior
   2.3. The time factor
   2.4. Do we need a new research paradigm?
3. Research approaches (and some pitfalls)
4. Conclusions and policy implications
References

Chapter 28
Automobile Demand and Type Choice
DAVID S. BUNCH

1. Introduction
2. Determinants of automobile demand
3. Auto-ownership models
4. Vehicle-purchase models
   4.1. Three MNL new car purchase models
   4.2. Nested MNLs of vehicle purchase
   4.3. Mixed MNL and revealed preference/stated preference joint estimation
5. Vehicle-holdings and usage models
   5.1. Discrete-continuous NMNLs
   5.2. Examples from the literature
6. Vehicle-transaction models
7. Conclusions
References

Chapter 29
Information Systems and Other Intelligent Transport System Innovations
PETER BONSALL

1. Introduction
   1.1. Dimensions of response
2. The impact of ITS on travellers’ knowledge of the transport system
   2.1. Modelling the absence of information
### Contents

2.2. Modelling the acquisition of information 486  
2.3. To equilibrate or not to equilibrate? 490  
2.4. Credibility and compliance 491  
3. Sources of data for modelling the impacts of ITS 492  
References 494

### Chapter 30

Transit-assignment Models  
JOAQUIN DE CEA and ENRIQUE FERNANDEZ  
1. Introduction 497  
2. Some basic concepts 499  
3. Formulations for the transit-assignment problem 502  
  3.1. Transit-assignment models without congestion 502  
  3.2. Transit-assignment models with congestion 504  
4. Final comments 506  
References 507

### Chapter 31

Models for Public Transport Demand and Benefit Assessments  
KJELL JANSSON and REZA MORTAZAVI  
1. Introduction 509  
2. A general framework on choice of mode and benefit estimation 510  
3. Basic characteristics of elasticity models 512  
4. Basic characteristics of assignment models 513  
  4.1. Introduction 513  
  4.2. The RDT model 514  
5. Basic characteristics of the multinomial logit model 515  
6. tasks and problems of the models 517  
7. Comparisons between models by use of examples 518  
  7.1. Assumptions 518  
  7.2. Example 1 519  
  7.3. Example 2 522  
  7.4. Conclusions of comparisons 524  
8. Conclusions 524  
References 525

### Chapter 32

Strategic Freight Network Planning Models  
TERRY L. FRIESZ  
1. Introduction 527  
2. Background 528  
3. The key commercial models 529
Chapter 33

Urban Freight Movement Modeling

GLEN D'ESTE

1. Introduction
2. The nature of urban freight
   2.1. Partitioning the urban freight market
   2.2. Measuring urban freight movements
3. Modeling framework
4. Steps in the modeling process
   4.1. Partitioning
   4.2. Zoning system
   4.3. Networks
   4.4. Trip generation
   4.5. Trip distribution
   4.6. Mode split
   4.7. Trip assignment
5. Other modeling issues
   5.1. Data availability
   5.2. Temporal variation
   5.3. Transient attractors
   5.4. Pace of change
6. Concluding remarks
References

Chapter 34

Value of Freight Travel-time Savings

GERARD DE JONG

1. Introduction
2. Classification of methods used in freight VTTS research
3. Summary of outcomes for road transport
4. Summary of outcomes for rail or combined transport
5. Summary of outcomes for inland waterways transport
References
   6.1. Recruitment and segmentation
   6.2. Contents of the experiments
   6.3. Model
7. Value of freight travel-time savings in the long run
8. Conclusion
References

Chapter 35
Modelling Performance: Rail
CHRIS NASH
1. Introduction
2. Characteristics of railways
   2.1. Multiplicity of outputs
   2.2. Complexity of the production process
   2.3. Operating environment and government intervention
3. Partial productivity measures
4. Total factor productivity
5. Explaining the performance of individual railways
6. Conclusions
References

Chapter 36
The Performance of Bus-transit Operators
BRUNO DE BORGER and KRISTIAAN KERSTENS
1. Introduction
2. Performance measurement in bus transit
   2.1. Performance concepts: Productivity, efficiency, and effectiveness
   2.2. Specification of inputs and outputs for performance measurement in the bus industry
3. Performance of bus operators
   3.1. Bus technology and performance: Some facts
   3.2. Determinants of bus transit productivity and efficiency
4. Conclusion
References

Chapter 37
Models of Airport Performance
PETER FORSYTH
1. Introduction
2. Modeling demand, congestion cost, and pricing
   2.1. Congestion models
1. Introduction 643
2. Optimization of liner shipping operations 645
3. Market-structure modeling 647
4. New theoretical perspectives on liner shipping 650
   4.1. The theory of contestability 651
   4.2. The theory of the core 652
5. Concluding remarks 653
References 655

Author Index 657

Subject Index 663