

TABLE OF CONTENTS

PART I INTRODUCTION

1	Introduction	3
1.1	Prologue	3
1.2	Motorist information systems and road-pricing	4
1.3	Objective of the book	5
1.4	Outline of the book	6
2	Motorist information systems: An introduction	9
2.1	Introduction	9
2.2	Benefits from motorist information systems	11
2.3	Possible adverse effects of motorist information systems	13
2.4	Wardrop's principles and motorist information systems	16
2.5	The relationship between concentration, overreaction, market penetration and Wardrop's principles	19
2.6	External effects and motorist information systems	22
2.7	Traffic generating properties of motorist information systems	27
2.8	The level of market penetration	28
2.9	The case of non-recurrent congestion	31
2.10	Motorist information systems as a tool for achieving government's objectives	32
2.11	Conclusion	33
3	Road-pricing: An introduction	35
3.1	Introduction	35
3.2	The theory: First-best?	35
3.3	Congestion-pricing: Pros and cons	40
3.4	Behavioural responses towards congestion-pricing	46
3.5	Implementing congestion-pricing	50
3.6	The Dutch failure to implement congestion-pricing	54
3.7	Conclusion	56

4 A stochastic route choice framework	58
4.1 Introduction	58
4.2 Perception and uncertainty in user equilibrium models: Relation to motorist information systems	59
4.3 A route choice model with stochastic travel costs and driver information ..	61
4.4 An extension of the route choice model: Costs of uncertainty	64
4.5 Conclusion	65
App.4.A An introduction to the bottleneck model	66

PART II THEORETICAL MODELS

5 Welfare economic analysis of motorist information in a one-route network	73
5.1 Introduction	73
5.2 One-link stochastic network deterministic user equilibrium model	74
5.3 Efficiency and equity issues of information	81
5.4 Conclusion	89
App.5.A Proof of Proposition 5.1	91
6 Welfare economic analysis of motorist information in a two-route network	94
6.1 Introduction	94
6.2 Some definitions	94
6.3 Two-route stochastic network deterministic user equilibrium model	95
6.4 Model experiments	101
6.5 Conclusion	105
App.6.A1 Proof of Proposition 6.1	106
App.6.A2 Proof of Proposition 6.2	110
7 Endogenous demand for motorist information	111
7.1 Introduction	111
7.2 SNDUE model with endogenous demand for information	111
7.3 Regulatory issues	117
7.4 Conclusion	123
App.7.A1 Proof of Proposition 7.1	125
App.7.A2 Derivation of Figure 7.3	127
8 Including the costs of uncertainty	128
8.1 Introduction	128
8.2 SNDUE models with costs of uncertainty	128
8.3 Information provision and system optimal behaviour	139
8.4 Conclusion	144
App.8.A1 Proof of Proposition 8.1	146
App.8.A2 Proof of Proposition 8.2	148
App.8.A3 Proof of Proposition 8.3	152

9	Motorist information in networks with multiple OD-pairs	154
9.1	Introduction	154
9.2	The network structure	154
9.3	The models	156
9.4	Model experiments	160
9.5	Conclusion	172
10	Simultaneous congestion-pricing and information provision	173
10.1	Introduction	173
10.2	Five regulatory regimes	174
10.3	Optimal congestion-pricing under various regulatory regimes	175
10.4	The relative performance of the various regulatory regimes	177
10.5	Conclusion	183

PART III SIMULATION MODELS

11	Simulation modelling: Recurrent congestion	187
11.1	Introduction	187
11.2	Four different types of information provision	188
11.3	Behavioural models	189
11.4	Simulation framework	195
11.5	Results of simulation experiments	201
11.6	Conclusion	212
12	Simulation modelling: Non-recurrent congestion	214
12.1	Introduction	214
12.2	Recurrent versus non-recurrent congestion	216
12.3	Information accuracy	217
12.4	The model	219
12.5	Model parameters	220
12.6	Results of the simulation experiments	222
12.7	Conclusion	230

PART IV EMPIRICAL MODELS

13	Radio traffic and variable message sign information; An empirical analysis	235
13.1	Introduction	235
13.2	The literature	236
13.3	The Amsterdam survey	237
13.4	The analysis	240
13.5	Conclusion	255

14 Empirical analysis of the work schedule flexibility	257
14.1 Introduction	257
14.2 The data	258
14.3 Analysis of the work start time	259
14.4 Implications for road-pricing and motorist information systems	268
14.5 Conclusion	269

PART V CONCLUSIONS

15 Summary, conclusions and future research directions	273
15.1 Summary	273
15.2 Conclusions	276
15.3 Future research directions	277
 References	 279
 Subject index	 289
 Author index	 291

LIST OF FIGURES

Figure 1.1	Structure of the book.	7
Figure 2.1	Network performance as a function of market penetration.	12
Figure 2.2	Predictive information and drivers' responses.	17
Figure 2.3	Iterative procedure for calculating perfect predictive information.	18
Figure 2.4	Travel time as a function of market penetration.	24
Figure 2.5	Information benefits to equipped drivers. Case 1.	24
Figure 2.6	Information benefits to equipped drivers. Case 2.	24
Figure 2.7	Relationship between quality of information and level of market penetration. Information collected via equipped drivers.	27
Figure 2.8	Relationship between quality of information and level of market penetration. Information collected via loop detectors in the road.	27
Figure 2.9	Market potential of motorist information system for two marginal cost curves (A and B).	30
Figure 3.1	Traditional diagram of congestion-pricing with linear curves.	38
Figure 3.2	Congestion-prices: Based on prevailing or predicted levels of congestion?	39
Figure 3.3	Compensation effects of congestion-pricing.	48
Figure 4A.1	Standard diagram of bottleneck model.	68
Figure 5.1	Graphical illustration of equilibrium model with informed and uninformed individuals.	77
Figure 5.2	Welfare effects for x-travellers.	82
Figure 5.3	Expected net private benefits for x (informed) and y (uninformed) travellers.	84
Figure 5.4	Welfare effects for y-travellers.	85
Figure 5.5	Impacts of probability of low capacity on ω	87
Figure 5.6	Impact of demand elasticity on ω	88
Figure 5.7	Impact of market penetration on ω	89
Figure 6.1	Example of an increase in welfare due to route switching by an informed road user.	101
Figure 6.2	Expected travel costs as a function of the expected number of informed drivers.	102
Figure 6.3	Expected saving in travel costs as a function of the expected number of informed drivers.	103
Figure 6.4	Relative welfare improvement as a function of the expected number of informed drivers.	104
Figure 6A.1	Expected usage declines both for group y and for group x when perfect information is taken away from group x.	109

Figure 7.1	Welfare effects of information.	112
Figure 7.2	Difference in expected net private benefits of the model with endogenous demand for information and the model in which no information is available.	115
Figure 7.3	Welfare effects of endogenous information.	116
Figure 7.4	The relationship between the price of information, subsidising information, and expected welfare.	119
Figure 7.5	Relationship between the price of information and welfare.	123
Figure 8.1	Model N and I: Case $N_1^1 < N_N < N_1^0$	132
Figure 8.2	Model N and I: Case $N_N < N_1^1 < N_1^0$	133
Figure 8.3	Expected network travel costs in model N and P.	135
Figure 8.4	Relative welfare improvement as a function of the value-of-uncertainty (β).	143
Figure 8.5	Relative welfare improvement as a function of the absolute value of the slope of the demand function.	144
Figure 9.1	Network structure.	155
Figure 9.2	Expected net welfare gain due to information provision to x-travellers as a function of the capacity shock $b_1^1 - b_1^0$ (Model P_x - Model N); $b_2 = 0.015$	161
Figure 9.3	Expected net welfare gain due to information provision to x-travellers as a function of the capacity shock $b_1^1 - b_1^0$ (Model P_x - Model N); $b_2 = 0.03$	162
Figure 9.4	Expected net welfare gain due to information provision to x-travellers as a function of b_2 (Model P_x - Model N).	163
Figure 9.5	Expected net welfare gain due to information to y-travellers as a function of the capacity shock $b_1^1 - b_1^0$ (Model P_{x+y} - Model P_x); $b_2 = 0.015$	164
Figure 9.6	Expected net welfare gain due to information to y-travellers as a function of the capacity shock $b_1^1 - b_1^0$ (Model P_{x+y} - Model P_x); $b_2 = 0.03$	165
Figure 9.7	Expected net welfare gain due to information to y-travellers as a function of b_2 (Model P_{x+y} - Model P_x).	166
Figure 9.8	Expected net welfare gain due to information provision to x-travellers as a function of b_3 (Model P^x - Model N); $b_2 = 0.02$	168
Figure 9.9	Expected net welfare gain due to information provision to x-travellers as a function of b_3 (Model P^x - Model N); $b_2 = 0.04$	169
Figure 9.10	Expected net welfare gain due to information provision to y-travellers as a function of b_3 (Model P^{x+y} - Model P^x); $b_2 = 0.02$	170
Figure 9.11	Expected net welfare gain due to information provision to y-travellers as a function of b_3 (Model P^{x+y} - Model P^x); $b_2 = 0.04$	171
Figure 10.1	Varying probabilities of cost shocks: indices of relative welfare improvement.	179

Figure 10.2	Varying congestion cost parameter volatility: indices of relative welfare improvement.	180
Figure 10.3	Varying demand characteristics with cost-shocks: indices of relative welfare improvement.	181
Figure 10.4	Varying demand characteristics with cost shocks and a free-flow cost differential: indices of relative welfare improvement.	182
Figure 10.5	Varying probabilities of cost shocks: flat fees and expected fine fees.	182
Figure 11.1	Road network used in simulation experiments.	197
Figure 11.2	Departure time structure.	198
Figure 11.3	Flow of control in simulation model.	200
Figure 11.4	Evolution of daily average travel time during a simulation run. $K0=8$, $bound=0$	202
Figure 11.5	Travel time as a percentage of the travel time under the model with $bound=0$ for three levels of congestion.	203
Figure 11.6	Number of routes used for models with different bounds and three levels of congestion.	204
Figure 11.7	Number of periods till steady state is reached for models with different bounds and three levels of congestion.	204
Figure 11.8	Evolution of drivers' switching propensity under model with different bounds and congestion level $K0=8$	205
Figure 11.9	Travel times compared to no information case. $K0=5$	207
Figure 11.10	Travel times compared to no information case. $K0=8$	207
Figure 11.11	Travel times compared to no information case. $K0=12$	208
Figure 11.12	Average daily travel times for drivers with and without information. $K0=5$, level of market penetration is 5%.	208
Figure 11.13	Daily travel time pattern for no and full market penetration. $K0=8$	209
Figure 11.14	Travel times compared to no information case. $K0=5$	210
Figure 11.15	Travel times compared to no information case. $K0=8$	210
Figure 11.16	Travel times compared to no information case. $K0=12$	211
Figure 12.1	Transport system without shocks.	216
Figure 12.2	Transport system with shocks.	217
Figure 12.3	From information detection to information provision.	218
Figure 12.4	Updating time and delay. Three cases.	219
Figure 12.5	Departure time structure.	220
Figure 12.6	Daily network wide travel time for 1 run. $upd=1$, $p=0.19$, $en_route_bound=0.05$	224
Figure 12.7	Benefits for different groups of drivers. $upd=1$, $p=0.19$, $en_route_bound=0.05$	224
Figure 12.8	Network wide performance as a function of market penetration for three updating times.	226
Figure 12.9	Effects of information for six incident rates. $upd=1$, $en_route_bound=0.05$	227
Figure 12.10	Effects of information for three incident rates.	

	upd=10, en_route_bound=0.05.	227
Figure 12.11	Dependency between updating frequency and incident rates. 50% market penetration, en_route_bound=0.05.	228
Figure 12.12	Effects of en_route_bound on network wide performance. upd=1, p=0.19.	229
Figure 12.13	Effects of en_route_bound on network wide performance. upd=10, p=0.19.	229
Figure 12.14	Network wide performance in relation to switching propensity, market penetration and information quality.	230
Figure 13.1	Major road network of the Amsterdam region.	238
Figure 13.2	Outline of the empirical analysis.	241
Figure 14.1	Work start time intervals.	263

LIST OF TABLES

Table 3.1	Assessment of the attractiveness of different types of congestion-pricing.	52
Table 4.1	Combination of features of network and individual characteristics.	60
Table 11.1	Information provision types.	188
Table 11.2	Three levels of network capacity.	198
Table 12.1	Model parameters.	222
Table 12.2	Experimental design of simulation experiments.	222
Table 13.1	Survey characteristics.	240
Table 13.2	Reference group of dummy variables.	243
Table 13.3	Estimation results of listening propensity to radio traffic information and route choice influence due to radio traffic information: Two ordered probit models.	244
Table 13.4	Estimation results of route choice influence due to RIA traffic information: Ordered probit model. Estimation results of satisfaction with alternative route: Multiple logit model.	247
Table 13.5	Bivariate ordered probit model of route choice adaptations due to radio traffic information and RIA traffic information	251
Table 13.6	Bivariate ordered probit models of willingness-to-pay for in-vehicle RIA traffic information and listening propensity to radio traffic information.	254
Table 14.1	Survey characteristics.	259
Table 14.2	Tobit estimation results of work flexibility intervals, first, second and third column. Logit estimation of satisfaction, fourth column.	261
Table 14.3	Results of indifferent and intolerable work start time intervals during the morning peak-hours.	265
Table 14.4	Workers' restrictions preventing them from having more flexible work start times during the peak-hours.	266