Sven Erlander

Cost-Minimizing Choice Behavior in Transportation Planning

A Theoretical Framework for Logit Models



Contents

1	Logit	Models for Spatial Interaction: Background	1
	1.1	Introduction	1
	1.2	Cost-Minimizing Behavior	3
	1.3	Intuitive Gravity Models and Most Probable State Approach	4
	1.4	User Equilibrium in a Network	6
	1.5	Econometric Models of Probabilistic Choice	6
	1.6	Luce's Axiomatic Derivation	7
	1.7	ARUM – Additive Random Utility Maximization – Approach	.7
	1.8	Structured or Nested Logit Models	8
	1.9	Transportation Problem in Linear Programming	8
	1.10	Lagrangian Methods of Deriving Logit Models	9
	1.11	Welfare Measures	10
2	Empi	rical and Policy Relevance of the New Paradigm	11
	2.1	Empirical Relevance	11
	2.2	Policy Relevance	12
3	Beha	vioral Foundations of Spatial Interaction Models	15
	3.1	Basic Ideas – Cost-Minimizing Behavior and Equilibrium	16
	3.2	Probability Models	
	3.3	Freedom of Choice	
	3.4	Cost-Minimizing Behavior	21
	3.5	The Simple (Multinomial) Logit Model Exhibits	
		Cost-Minimizing Behavior	22
	3.6	Cost-Minimizing Behavior Implies the Logit Model	23
	3.7	Welfare Measure	24
	3.8	Graphical Test	24
	3.9	Some Particular Discrete Choice Models	25
	3.10	Equilibrium	25
	3.11	Choice of Origin, Destination and Route	
	3.12	Choice of Origin, Destination, Mode and Route	

ĺ,

.

	3.13	Comments	9
	3.14	Notes	9
	3.15	About Notation	0
Pa	rt I 🛛	Cost-Minimizing Behavior: Constant Link Costs	
4	Logit	Models for Discrete Choice	3
	4.1	Preliminaries	3
	4.2	The Simple (Multinomial) Logit Model	
		4.2.1 Formal Derivation of the Simple (Multinomial)	
		Logit Model	6
	4.3	The General Logit Model for Cost-Minimizing Behavior	
	4.4	Axiomatic Derivations of Logit Models 44	
		4.4.1 Axioms for Cost-Minimizing Behavior 4	
		4.4.2 Axioms for Payoff-Maximizing Behavior	
	4.5	Axioms for ARUM Derivation 4	9
		4.5.1 ARUM Derivation of the Simple (Multinomial)	
		Logit Model 4	9
		4.5.2 Properties of the Expected Achieved Perceived Utility 5	1
		4.5.3 Generalized Extreme Value Model 5	2
	4.6	Extensions	3
		4.6.1 Comments on the Cost Function	3
		4.6.2 Different Interpretations of the Same Model	4
		4.6.3 Cost-Minimizing Behavior for one Decision	Ň.
		Maker Making N Repeated Decisions	5 `
	4.7	Comments	7
	4.8	Notes	0
5	Some	Particular Logit Models	3
	5.1	Introduction	
	5.2	Stochastic Route Choice	3
	5.3	The Multi-Attribute Discrete Choice Model	4
	5.4	Generalized Cost	5
	5.5	The Gravity Model for Trip Distribution	6
	5.6	The Gravity Model for Trip Distribution with Several	
		Cost Attributes	9
	5.7	Structured (Nested) Logit Models 7	1
		5.7.1 The Structured Logit Model: The Joint Logit Model	3
		5.7.2 The Standard Nested Logit Model 7	7
		5.7.3 The Standard ARUM Nested Approach 8	1
	5.8	The Logit Model with Individual Cost Values	1
	5.9		2
	5.10	Comments and Extensions 8	4
	5.11	Notes	6

6	Welf	are, Benefit and Freedom of Choice	87
	6.1	Introduction	87
	6.2	Achievement Measure	88
	6.3	Freedom of Choice: Preliminaries	89
	6.4	Freedom of Choice Measure	
		6.4.1 Freedom of Choice in the Probabilistic Case	93
	6.5	Welfare Measures	94
		6.5.1 Welfare Measure for the Simple Logit Model	94
		6.5.2 Numerical Illustrations	97
		6.5.3 Welfare Measure for the General Logit Model	99
		6.5.4 Welfare Measures for some Particular Models	100
		6.5.5 Welfare Measure for the Stochastic Route Choice Model	100
		6.5.6 Welfare Measure for the Multi-Attribute Case	101
		6.5.7 Welfare Measure for Structured (Nested) Logit Models	101
		6.5.8 Welfare Measure for Gravity Model for Trip Distribution	103
		6.5.9 Welfare Measures for Models	
		with Socioeconomic Factors	103
	6.6	Extensions	104
		6.6.1 Extended Benefit Measure	104
		6.6.2 A Lower Bound on Observed Negative Entropy	105
		6.6.3 Value of Time	106
	6.7	Comments	106
		6.7.1 Revealed Freedom of Choice, Diversity	
		of Choice, Flexibility of Choice	106
		6.7.2 Freedom of choice: Advantage and Achievement	106
		6.7.3 Entropy and Freedom of Choice	107
		6.7.4 Welfare and Benefit Measures	108
	6.8	Notes	108
7		phical Tests of Cost-Minimizing Behavior	
		git Models	
	7.1	Introduction	109
	7.2	Testing for Cost-Minimizing Behavior in the Simple	
		Logit Model	
		7.2.1 Graphical Test of Cost-Minimizing Behavior	112
		7.2.2 Asymptotic Distribution of the Observed	
		Negative Entropy	
		7.2.3 Simulation Experiments	
		7.2.4 Figures	
		7.2.5 Final Remarks	
	7.3	Multi-Attribute Discrete Choice Models	
		7.3.1 Graphical Test of Cost-Minimizing Behavior	
	7.4	Structured Logit Models	
		7.4.1 Graphical Test of Cost-Minimizing Behavior	
	7.5	Comments and Extensions	
	7.6	Notes	122

Part II Equilibrium

8	Equi	librium	125
	8.1	Introduction	
	8.2	Smith's Cumulative Cost Function and Equilibrium	125
	8.3	Route Choice	
		8.3.1 Continuous Approximation	
	8.4	Choice of Origin, Destination and Route	
		8.4.1 Most Probable Trip Pattern	
		8.4.2 Most Probable Flow	
		8.4.3 Continuous Approximation	
	8.5	Choice of Origin, Destination, Mode and Route	
		8.5.1 Continuous Approximation	
	8.6	Comments and Extensions	140
	8.7	Notes	
9	Арр	endix	143
	9.1	Representation Theorem for Cost-Minimizing	
		Probability Distributions	143
	9.2	Likelihood and Entropy of a Sample	
	9.3	Maximum Entropy	
	9.4	Maximum Likelihood	
Re	eferen	ces	149 [`] `

.

,