The FHWA Travel Model Improvement Program Workshop over the Web

The Travel Model Development Series: Part I – Travel Model Estimation

presented by
Thomas Rossi
Cambridge Systematics, Inc.

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Webinar Objectives
Learning

- Intended for those who have a low level of familiarity with the estimation and validation of travel models
- Introduces
  - Development of model estimation data sets
  - Structures of various model components
  - Procedures for estimating models
- Does not train participants in model estimation procedures

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Webinar Outline

- Session 1: Introduction – October 16, 2008
- Session 2: Data Set Preparation – November 6, 2008
- Session 3: Estimation of Non-Logit Models – December 11, 2008
- Session 4: Estimation of Logit Models – February 10, 2009

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Webinar Outline (continued)

- Session 5: Application and Validation of Logit Models – March 12, 2009
- Session 6: Advanced Topics in Discrete Choice Models – April 14, 2009
- Session 7: Trip Assignment – May 7, 2009
- Session 8: Evaluation of Validation Results – June 9, 2009

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Homework

(You thought you finished this forever decades ago!)

- Exercise will be assigned at the end of each session, based on some of the information discussed
- May require generally available software (e.g., Excel, text editor, etc.), but not specialized software such as model estimation or application programs
- You may e-mail questions on the homework to us up to one week before the next session
  - trossi@camsys.com, ypopuri@camsys.com
- Homework will be reviewed during the first part of the next session

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Types of Urban Models

- Four-step models
- Three-step models (no mode choice)
- Tour and activity based models

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Model Components
Four-Step Models

- Trip production
- Trip attraction
- Trip distribution
- Mode choice
- Assignment
- Time of day
- Auto ownership
- Other
  - Trucks/freight
  - External trips
  - Other?

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The Model …

- … takes a set of *input data* …
- … and converts it to a set of *output data* …
- … using a set of *mathematical models* …
- … which use *parameters* to perform the conversions
- The input and output data for individual model components may be temporary, or interim

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Model Parameters …

… may be:

- Estimated (usually from local data),
- "Borrowed" from another model or other data source, or
- Asserted, based on knowledge from other sources

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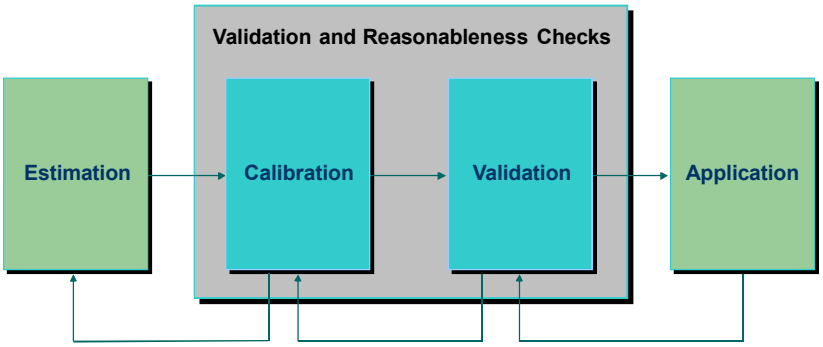
The Model Development Process



Model Development Process

- Have a model development plan
- Assemble necessary data for estimation, validation, and application
- For each component
  - Define the mathematical model and the model structure
  - Estimate (or otherwise obtain) the parameters
  - Validate the model (a whole ‘nother topic!)
  - Recalibrate the parameters as necessary

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Model Development Process (continued)

- Validate overall model system, including forecast years
  - Recalibrate as necessary
- Don't forget documentation!

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Model Application Process

- Overall inputs
  - Socioeconomic data
  - Networks (highway, transit)
  - Other (parking costs, auto operating costs, etc.)
- Overall outputs
  - Link volumes → VMT
  - Link speeds → VHT
  - Transit boardings, line volumes
  - Trips by O-D, mode, purpose, time of day, etc.

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Some Model Component Examples

- Trip generation
  - Input – Socioeconomic data
  - Output – Trip ends
- Trip distribution
  - Input – Trip ends/network skims
  - Output – Trip tables

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Some Model Component Examples (continued)

- Mode choice
  - Input – Trip tables/network skims
  - Output – Trip tables by mode
- Highway assignment
  - Input – Trip tables for auto mode/highway network
  - Outputs – Volumes/speeds

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Common Model Component Formulations

- Simple factoring
- Cross-classification
- Regression
- Logit (multinomial, nested)
- Assignment

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Model Estimation Data Sources

- Household activity/travel survey (household, trip level)
- Transit on-board survey
- Critical nonsurvey data
  - Socioeconomic data
  - Networks
  - Other (area types, parking costs, auto operating costs, etc.)

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Model Types

Model Component	Typical Model Type	Usual Estimation Data Source	Other Basic Data
Auto ownership	Multinomial/ ordered response logit	Household survey (household file)	Socioeconomic, network (skims)
Trip production	Cross-classification	Household survey (household file)	Socioeconomic
Trip attraction	Linear regression	Household survey (trip file)	Socioeconomic
Trip distribution	Gravity/ multinomial logit	Household survey (trip file)	Socioeconomic, network (skims)

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Model Types (continued)

Model Component	Typical Model Type	Usual Estimation Data Source	Other Basic Data
Time of day	Simple factoring	Household survey (trip file)	
Mode choice	Multinomial/ nested logit	Household survey (trip file)	Socioeconomic , network (skims)
Highway assignment	Static user equilibrium		Highway network
Transit assignment	All-or-nothing, multipath		Transit network

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Regression Model

$Y = B_0 + B_1 X_1 + B_2 X_2 + \ldots + B_n X_n$

where:

Y = Dependent variable

B_i = Estimated coefficients

X_i = Independent variables

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Regression Model Example
Trip Attraction Model

HBO Attractions = 1.32 (service employment)

+ 1.46 (retail employment)

+ 0.76 (households)

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Cross-Classification Model

Independent Variable #2	Independent Variable #1			
	Value 1	Value 2	…	Value n
Value 1	Dep var value	Dep var value		Dep var value
Value 2	Dep var value	Dep var value		Dep var value
…				
Value n	Dep var value	Dep var value		Dep var value

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Cross-Classification Model Example
Trip Production Model – Home Based Shop Trips

Persons/ Household	Vehicles/Household			
	0	1	2	3+
1	0.294	0.333	0.333	0.333
2	0.377	0.465	0.619	0.619
3	0.425	0.515	0.619	0.619
4+	0.433	0.601	0.740	0.767

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Gravity Model
Trip Distribution

$$T_{ij} = \frac{P_i A_j F(t)_{ij} K_{ij}}{\sum_j P_i A_j F(t)_{ij} K_{ij}}$$

where:

- T_{ij} = number of trips produced in zone i and attracted to zone j
- P_i = trips produced in zone i
- A_j = trips attracted to zone j
- $F(t)_{ij}$ = friction factor from i to j (based on impedance t)
- K_{ij} = K factor from i to j
- i = origin zone
- j = destination zone

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Multinomial Logit Model

$$P(\text{alt } 1) = \frac{\exp(V_1)}{\sum_j \exp(V_j)}$$

where:

- V_j = Deterministic component of utility of alternative j
- exp = exponential function (e^x)

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Multinomial Logit Model
Utility Function

$$V_{ij} = B_{0j} + B_{1j} X_{1ij} + B_{2j} X_{2ij} + \ldots + B_{nj} X_{nij}$$

where:

V_{ij} = Utility (deterministic component) of alternative j for individual i

X_{kij} =Attributes (k = 1,n) for individual i for alternative j

B_{kj} =Estimated coefficients for attribute k for alternative j

B_{0j} = Alternative-specific constant for alternative j

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Multinomial Logit Model Example
Vehicle Availability Model

Variable	Vehicle Availability Level			
	0	1	2	3+
Constant	Base alt (U = 0)	0.64	-0.45	-2.29
1 worker in household (0,1)		0.83	1.10	1.66
2+ workers in household (0,1)		0.54	2.47	3.32
Low-med income (0,1)		1.16	2.18	2.26
High-med income (0,1)		0.87	3.04	3.64
High income (0,1)		1.78	4.31	5.28
% employment within 15 min		-0.03	-0.08	-0.12

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Multinomial Logit Model Example
Vehicle Availability Model (continued)

Utility functions:

$U_0 =$ 0

$U_1 =$ 0.64 + 0.83 (1 worker) + 0.54 (2+ worker)
+ 1.16 (Low-medium income) + 0.87 (High-medium income)
+ 1.78 (High income) -0.03 (% employer w/in 15 min)

$U_2 =$ -0.45 + 1.10 (1 worker) + 2.47 (2+ worker)
+ 2.18 (Low-medium income) + 3.04 (High-medium income)
+ 4.31 (High income) -0.08 (% employer w/in 15 min)

$U_3 =$ -2.29 + 1.66 (1 worker) + 3.32 (2+ worker)
+ 2.26 (Low-medium income) + 3.64 (High-medium income)
+ 5.28 (High income) -0.12 (% employer w/in 15 min)

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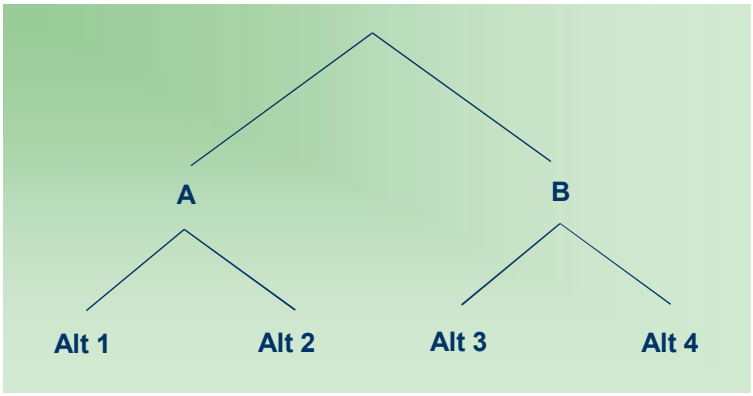
Nested Logit Model



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Nested Logit Model

$$P(\text{alt 1} \mid A) = \frac{\exp(V_1)}{\exp(V_1) + \exp(V_2)}$$

$$P(A) = \frac{\exp[f(V_1, V_2)]}{\exp[f(V_1, V_2)] + \exp[f(V_3, V_4)]}$$

$$P(\text{alt 1}) = P(\text{alt 1} \mid A)\ P(A)$$

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Highway Assignment

- Static equilibrium assignment
  - Assumes O-D travel times along all used paths are equal
- Link travel time is a function of travel time, e.g.,

  $T = T_0 + [\ 1 + a\ (v/c)^b\ ]$

  where:

  T = link travel time

  T_0 = free flow travel time

  v = link volume

  c = link capacity

  a, b model parameters

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Model Parameter Development
Example

- Estimated (from household survey)
  - Trip generation rates
  - Friction factors for gravity model
  - Time of day percentages by purpose
- Borrowed
  - Mode choice utility coefficients (from other model)
- Asserted
  - BPR function parameters a, b (from literature)
  - K-factors (all set to 1.0)

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