MODE CHOICE MODELING FOR LONG-DISTANCE TRAVEL

15 January 2013
92nd Annual Meeting of the Transportation Research Board, Washington D.C.
Agenda

1. Introduction
2. Long-distance travel demand
3. R³Logit long-distance mode choice model
4. Parameters
5. Lessons learned
INTRODUCTION

Mode Choice Modeling for Long-Distance Travel
Relevance of long-distance mode choice

- 2% of trips are long-distance, contributing 31% to VMT
- High-speed rail projects
- Costly infrastructure investments for long-distance travel
- Regional accessibility affects economic prosperity (Krugman)
- Even if focus is on auto travel, mode choice is relevant
  - Auto occupancy
  - Remove transit users from highway
Existing models

- Few mode long-distance choice models published
- Most refer to a very specific corridor
- Most apply econometric parameter estimation
LONG-DISTANCE TRAVEL DEMAND

Mode Choice Modeling for Long-Distance Travel
Relevant publicly available data (U.S.)

- American Travel Survey (ATR) 1995
- National Household Travel Survey (NHTS) 2002
- National Household Travel Survey (NHTS) 2009
- National Household Travel Survey (NHTS) 2015
- Bureau of Transportation Statistics: Air travel data
Model Concept

- State population
- NHTS data
- BTS air travel data

1. Synthesize missing states
2. Derive nation-wide control total
3. Expand NHTS
4. Disaggregate state-to-state trips to TAZ
5. Feed trips into $R^3$Logit
Synthesize NHTS Records
Expansion of NHTS Dataset

<table>
<thead>
<tr>
<th>Element</th>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Number of NHTS air traveler records</td>
<td></td>
<td>3,302</td>
</tr>
<tr>
<td>B Number of yearly air travelers (BTS)</td>
<td></td>
<td>85,191,050</td>
</tr>
<tr>
<td>C Number of daily air travel tours</td>
<td>= B / 365</td>
<td>233,400</td>
</tr>
<tr>
<td>D Tours per NHTS record</td>
<td>= C / A</td>
<td>71</td>
</tr>
</tbody>
</table>

Assumption: Each NHTS record represents 71 long-distance travel tours.
Disaggregation of Trips

\[
\text{trips}_{\text{zone}_i, \text{zone}_j} = \text{trips}_{\text{state}_a, \text{state}_b} \cdot \sum_{\text{zone}_k \in \text{State}_a} \left( \sum_{\text{zone}_l \in \text{State}_b} \text{weight}_{\text{zone}_k, \text{zone}_l} \right)
\]

\[
\text{weight}_{\text{zone}_i, \text{zone}_j} = \left( \lambda \cdot p_i + (1 - \lambda) \cdot e_i \right) \cdot \left( \mu \cdot p_j + (1 - \mu) \cdot e_j \right) \cdot \exp(\beta \cdot d_{i,j})
\]

Population & employment at origin
Population & employment at destination
Distance
Assignment of Auto Trips
LONG-DISTANCE MODE CHOICE MODEL

Mode Choice Modeling for Long-Distance Travel
Nesting Structure

Person trips

Auto
- Drive-alone
- Shared-ride 2*
- Shared-ride 3*
- Shared-ride 4+*

Transit*
- Bus
- Rail*
- Air*

* Carries a mode-specific constant
Utility for auto modes

\[ u_{i,j,m,p} = ivtc \cdot tt_{i,j,m} + ovtc \cdot autoEgr + prkc_p \cdot \frac{0.5 \cdot p_j}{occ_m} + aocc_p \cdot dist_{i,j} \cdot aoc \]
Utility for Transit Modes

\[
    u_{i,j,m,p} = ivtc \cdot tt_{i,Stat,auto} + ovtc \cdot trnAcc_m + ivtc \cdot tt_{iStat,jStat,m} + ntrc \cdot trnsf_{iStat,jStat,m} + \\
    trfc_p \cdot fare_{iStat,jStat,m} + tfqc_p \cdot \frac{frqu_{iStat,jStat,m}}{dist_{i,j}} + ovtc \cdot trnEgr_m + ivtc \cdot tt_{jStat,j,auto}
\]

- Travel time from origin to station
- Access time
- Transit travel time
- Number of transfer

- Fare
- Frequency
- Egress time
- Travel time from station to destination
Access to and Egress from Transit
## Calibration

<table>
<thead>
<tr>
<th>Mode</th>
<th>Observed share</th>
<th></th>
<th>Mode-specific constants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Business</td>
<td>Personal</td>
<td>Commute</td>
</tr>
<tr>
<td>Auto</td>
<td>68%</td>
<td>75%</td>
<td>92%</td>
</tr>
<tr>
<td>Drive-alone</td>
<td>31%</td>
<td>10%</td>
<td>66%</td>
</tr>
<tr>
<td>Shared-ride 2</td>
<td>22%</td>
<td>32%</td>
<td>17%</td>
</tr>
<tr>
<td>Shared-ride 3</td>
<td>8%</td>
<td>16%</td>
<td>6%</td>
</tr>
<tr>
<td>Shared-ride 4</td>
<td>7%</td>
<td>17%</td>
<td>3%</td>
</tr>
<tr>
<td>Transit</td>
<td>32%</td>
<td>25%</td>
<td>8%</td>
</tr>
<tr>
<td>Bus</td>
<td>13%</td>
<td>7%</td>
<td>2%</td>
</tr>
<tr>
<td>Rail</td>
<td>2%</td>
<td>1%</td>
<td>5%</td>
</tr>
<tr>
<td>Air</td>
<td>17%</td>
<td>16%</td>
<td>1%</td>
</tr>
</tbody>
</table>
HEURISTICALLY DERIVED PARAMETERS

Mode Choice Modeling for Long-Distance Travel
Econometrics versus Heuristics

• Most models use econometrically estimated parameters
• Small sample size limits robustness of estimation
• Often leads to large constants
Reviewed Papers

Sample Size

[B] Baik et al. (2008)
[R] $R^3$Logit
[Y] Yao, Morikawa (2005)
In-Vehicle Time Parameters

[B] Baik et al. (2008)
[R] R³Logit
Cost Parameters

-0.62 [M]  -0.04 [M]  -0.0309 [B]  -0.0224 [Y]  -0.0173 [WK]
-0.0328 [G]  -0.0318 [Bt]  -0.0242 [K]  -0.0111 [G]
-0.0333 [Y]

[B] Baik et al. (2008)
[R] R3Logit
[Y] Yao, Morikawa (2005)
Mode-Specific Constants

-11.3
[Y]

-3.4
[G]

-0.5
[Bt]

-0.3
[RM]

0.9
[RM]

0

2.2
[R]

1.9
[Bt]

1.9
[K]

1.9
[Y]

6.3
[WK]

15.4
[W]

18.0
[W]

[R] \( R^3 \)Logit
[Y] Yao, Morikawa (2005)
# Sensitivity Analysis

<table>
<thead>
<tr>
<th>Mode</th>
<th>Base</th>
<th>Transit Scenarios</th>
<th>Gas Price Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>11 buses per day</td>
<td>15 buses per day</td>
</tr>
<tr>
<td>Drive-alone</td>
<td>11.2%</td>
<td>-0.3%</td>
<td>-0.7%</td>
</tr>
<tr>
<td>Shared-ride</td>
<td>18.9%</td>
<td>-0.3%</td>
<td>-0.8%</td>
</tr>
<tr>
<td>Bus</td>
<td>43.0%</td>
<td>3.7%</td>
<td>8.4%</td>
</tr>
<tr>
<td>Rail</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Air</td>
<td>26.9%</td>
<td>-3.1%</td>
<td>-7.0%</td>
</tr>
</tbody>
</table>
LESSONS LEARNED
Mode Choice Modeling for Long-Distance Travel
Lessons Learned

• Teaming with Amtrak and bus providers helps a lot
• Pay attention to trip duration
• Limit party size ($R^3$Logit: 7)
• Model depends on representing travel options correctly, less than on fine-tuned calibration