Mode Split

John K. Abraham

CE 7630

Wayne State University

‘4-steps’ of demand modeling

- Trip Generation (land-use & economic factors determine how many trips people will make)
- Trip Distribution (determining where trips start and end)
- Mode-choice (determination of how you get there, e.g., bus, walk, auto, etc.)
- Trip Assignment (determination of which path you take from your trip origin to your trip destination)

TRANSIT MODES
Mode Split / Choice

- Several types of math models can be used
- Aggregate models (used for a group of trips)
  - trip end (used after trip generation and before trip distribution)
  - trip interchange (used after trip distribution)
    - methods include: multiple regression, cross classification, and diversion curves
Mode Split / Choice

- **Disaggregate models**
  - used to model individual trip making behavior
  - probabilistic (assumes a probability distribution of user behavior)
  - based on the utility (or disutility) of a particular mode choice
    - e.g. probit or logit models are used

- **All models require information on**
  - trip (type)
  - tripmaker preferences
  - transportation system (travel time and other characteristics)

Trip End Models:

These models are applied before trips are distributed, and predict transit share as a function of independent variables such as ...

- auto ownership in the zone
- residential density
- distance from CBD (central business district)
- income level
- others
Trip End Model (PATS)

Cross classification

<table>
<thead>
<tr>
<th>Auto per household</th>
<th>Zones &lt;1mi from CBD</th>
<th>Zones &gt; 1mi NRD 12⁺</th>
<th>NRD 12⁺ NRD &lt; 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>77</td>
<td>88</td>
<td>61</td>
</tr>
<tr>
<td>1</td>
<td>35.5</td>
<td>53.5</td>
<td>36</td>
</tr>
<tr>
<td>2 or more</td>
<td>13.5</td>
<td>31.5</td>
<td>20.5</td>
</tr>
</tbody>
</table>

\[ \log Y_s = 3.30 - 0.91 \log X \]

\[ Y_0 = 84.02X - 0.094X^2 \]

\[ Y_1 = 3.04 + 3.2X - 0.026X^2 \]

\[ Y_{2+} = 16.4 + 3.6X - 0.0334X^2 \]

Variables
- Auto Ownership
- Net residential Density
- Distance from CBD

Trip Generation by Mode
- Highways System
- Automobile Person Trip Distribution
- Highway Traffic Assignment
- Transit System
- Transit Person Trip Distribution
- Transit Traffic Assignment

Auto

Transit

Trips to CBD

School

Other

Y=transit trips/1000 persons
X=Net Residential density
Y₀=transit trips/1000 persons with no cars
Comments / Critique

- Trip end model tries to assign modes before knowing where they are going.
- Based on aggregation of relationships exhibited in a region – not transferable
- Changes to transit system in the future will have no effect on the split / is not incorporated
  - This may lead to continuing degradation of transit services / reduce funding
- Trip-end models are suitable for small urban areas where transit is basically a “social service”, or in developing countries where mode choice is almost completely determined by income & auto ownership

Trip interchange models:

- These models are applied after trip distribution, and predict transit share as a function of ...
  - relative travel time between competing modes
  - relative travel cost
  - economic status of tripmakers
  - relative service
- All other variables (e.g. trip length, population density...) are assumed to be correlated to these characteristics
  - uses multiple regression
  - must be recalibrated for different regions of the country
Mode Split Function of:

Variables
Relative Travel Time TTR
Relative travel cost CR
Economic status EC
Relative travel service L
Work Trip Modal Split Curves

Comments / critique

- Some level of transferability offered
- Only requires a small database to calibrate the model (for a metro area)
- Suggest fairly optimistic outlook for transit
  - Developed based on data from Bay Area, Philadelphia, Washington
Disaggregate models

- Individual choices
- Probability of choosing a mode among available alternatives
- Choice based on behavioral variables
- Predominant mathematical formulation is the LOGIT function

Concept of Utility

- *Utility* Function measures the degree of satisfaction that people derive from their choices.
- A *disutility* function represents the generalized cost associated with each choice
Example 2 -- 3 Utility Equations

Proposal:
30% chance of winning $500
70% chance of winning $2000

$U = 3X$
$U = X^{2/3}$
$U = X^{1.2}$

EMV = 0.3*500+0.7*2000 = $1550
EUV=30% (U @ X=500)+70%(U @ X = 2000) = 4650 utils
CE=X @ U=EUV = 4650/3 = 1550
RP = EMV-CE = 0

| $\$|$ | $U$ |
|---|---|
| 2500 | 6 |
| 5000 | 10 |
| 7500 | 12 |
| 10000 | 13.5 |
The Logit Model

**model form:**

\[ P_i = \frac{e^{U_i}}{\sum_j e^{U_j}} \]

- \( P_i \) = Probability of an individual choosing alternative i
- \( U_i \) = Utility function of mode i
- \( N \) = set of modal alternatives
- \( e \) = base of natural logarithm

where \( U_j = f(X_{j,k}) \)

Typical utility structure:

\[ U_j = a_0 + a_1 \{ \text{travel time} \} + a_2 \{ \text{wait time} \} + a_3 \{ \text{cost} \} \]

Nested Logit Mode Choice

- A model that quantifies the decision on the type of trip (car, bus, walk...) people will take in the region
- Some socioeconomic factors, used as input for the travel demand as well as logit models, will be predicted using a ‘trend’ technique called the Holt model, within the OFM forecasts used for Growth Management
- This type of mode choice analysis is required by the Federal Transit Administration for studying light rail and other forms of public transportation
- In addition, we can also use these assumptions to model bike and pedestrian travel patterns
## Nested Logit Mode Choice Structure

### Example: Airport Travel

<table>
<thead>
<tr>
<th>Auto</th>
<th>Door-to-Door</th>
<th>Scheduled Bus</th>
<th>Public Transit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rental Car</td>
<td>Shared-Ride Van</td>
<td>Taxi</td>
<td>Off-Airport Terminal</td>
</tr>
<tr>
<td>Drop-off</td>
<td></td>
<td>Limousine</td>
<td>Access</td>
</tr>
<tr>
<td>Park</td>
<td></td>
<td></td>
<td>Drop-off</td>
</tr>
<tr>
<td>Lot</td>
<td></td>
<td></td>
<td>Park</td>
</tr>
<tr>
<td>Short-Term</td>
<td></td>
<td></td>
<td>Taxi</td>
</tr>
<tr>
<td>Long-Term</td>
<td></td>
<td></td>
<td>Transit</td>
</tr>
<tr>
<td>Off-Airport</td>
<td></td>
<td></td>
<td>Airport Bus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stop</td>
</tr>
</tbody>
</table>
Comments / Critique

- aggregation of choices to the zonal level - taking an average of user's utilities and computing the probability of modal choice may produce different results than taking the average of computed probabilities
- model is sensitive to policy issues
- only requires a small database to calibrate the model (for a metro area)
- transferable to other, similar areas
- explains user behavior (aggregate models do not)