A Transit Route Choice Model
for Application in
Dynamic Transit Assignment

Alireza Khani, Tyler Beduhn, Jennifer Duthie, Stephen Boyles, Ehsan Jafari
Center For Transportation Research
University of Texas at Austin

Presentation at the 5th TRB Conference on Innovations in Travel Modeling (ITM)
Apr 27-30 2014, Baltimore MD
Presentation Outline

- Background
- Data
- Model Estimation
- Application
- Conclusions
Background

• Advanced transportation models: DTA and ABM

• A schedule-based transit (passenger) assignment model

• User behavior: The backbone of the assignment model
Background

• The transit assignment model (FAST-TrIPs):
  – Stochastic: logit route choice
  – Dynamic: vehicle schedule instead of average headway
  – Realistic: explicit modeling of vehicle capacity
  – Compatible with DTA and ABM:
    • Person-based model
    • Models tours (direction and departure/arrival time)
    • Higher time resolution
Background

• The transit assignment model (FAST-TrIPs):
  – A hyperpath model:
    • Generates schedule-based paths for each ODt
    • Takes into account either PAT or PDT (a departure time choice model is involved)
  – Logit model can take into account:
    • Waiting, walking and in-vehicle time
    • Transfer penalty
    • Route type, fare
    • Trip purpose, user type, and VOT
Background

• Objective:
  – To calibrate the assignment model for Austin region:
    • To estimate a route choice model
    • Implement it in the assignment model
Data

• On-board survey data
  – Collected by Capital Metro in winter and spring 2010
  – Riders were asked about:
    • Current route
    • Origin/destination location (geocoded)
    • Access/egress mode (walk, bike, drive or transfer)
    • Approximate boarding location
    • Demographics, trip purpose and payment type
Data

• On-board survey data

A Constrained Transit Shortest Path Algorithm
Data

• On-board survey data

Access Time:
Transfer Time:  +
Egress Time:
In-vehicle Time:  +  +

Number of transfers: 2
Fare: $1/local + $2.75/regional
Waiting time*: Min \{H/2, 2.28 + 0.29H, 13.3\}

* Fan and Machemehl 2009
Data

• GTFS: General Transit Feed Specification
  – Transit network:
    • Stop location
    • Route alignment
  – Transit schedule:
    • Vehicle arrival/departure time at each stop

• APC: Automated Passenger Count
  – Collected by Capital Metro (available for winter and spring 2013)
  – Boarding and alighting of each vehicle at each stop
  – Rotating 22% sample ➔ data available for all vehicle trips
Model Estimation

• Choice set generation
  – The hyperpath model generates the choice set:
    • Stated origin-destination
    • Within a time range around the survey time
    • A priori parameters (walking, waiting, in-vehicle and transfer)
  – Elementary paths are extracted by multiple random draws
  – Unique paths and their attributes are stored
Model Estimation

• Choice set generation
## Model Estimation

<table>
<thead>
<tr>
<th>Path Attributes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTR</td>
<td>Number of transfers between routes</td>
</tr>
<tr>
<td>IWT</td>
<td>Initial waiting time</td>
</tr>
<tr>
<td>IVT</td>
<td>Sum of the in-vehicle times</td>
</tr>
<tr>
<td>TRT</td>
<td>Sum of waiting times for making transfers</td>
</tr>
<tr>
<td>TRD</td>
<td>Sum of walking times for making transfers</td>
</tr>
<tr>
<td>ACT</td>
<td>Walking time for access from the origin</td>
</tr>
<tr>
<td>EGT</td>
<td>Walking time for egress to the destination</td>
</tr>
<tr>
<td>LocFare</td>
<td>Sum of fare for the local service rides</td>
</tr>
<tr>
<td>RegFare</td>
<td>Sum of additional fare for the regional service rides</td>
</tr>
<tr>
<td>HW</td>
<td>Headway of the first route in the path</td>
</tr>
<tr>
<td>Reg</td>
<td>Binary indicating whether or not a regional route is used</td>
</tr>
</tbody>
</table>
## Model Estimation

<table>
<thead>
<tr>
<th>User Characteristics</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>Gender (1: female, 0: male)</td>
</tr>
<tr>
<td>Frequent</td>
<td>Frequent transit user (using transit more than 3 days a week)</td>
</tr>
<tr>
<td>Income</td>
<td>Median of income range</td>
</tr>
<tr>
<td>LocPay</td>
<td>Binary indicating if the passenger pays local services</td>
</tr>
<tr>
<td>RegPay</td>
<td>Binary indicating if the passenger pays for regional services</td>
</tr>
<tr>
<td>OrigPurpose</td>
<td>Trip origin purpose</td>
</tr>
<tr>
<td>DestPurpose</td>
<td>Trip destination purpose</td>
</tr>
</tbody>
</table>
Model Estimation

• Estimation Process:
  – Input data:
    • 2,718 observations
    • 1,655 used for estimation:
  – Estimation Tool:
    • BIOGEME
  – Model Selection Criteria:
    • T-test (on individual variables)
    • Specification test (on $\rho^2$)
## Model Estimation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Standard Error</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_{IVT}$</td>
<td>-0.0733</td>
<td>0.0117</td>
<td>-6.24</td>
</tr>
<tr>
<td>$\beta_{IWT}$</td>
<td>-0.208</td>
<td>0.0193</td>
<td>-10.76</td>
</tr>
<tr>
<td>$\beta_{WALK}$</td>
<td>-0.767</td>
<td>0.0981</td>
<td>-7.82</td>
</tr>
<tr>
<td>$\beta_{WALK,FREQ}^*$</td>
<td>0.230</td>
<td>0.0958</td>
<td>2.40</td>
</tr>
<tr>
<td>$\beta_{NTR}$</td>
<td>-5.92</td>
<td>0.269</td>
<td>-21.98</td>
</tr>
<tr>
<td>$\beta_{TRT}$</td>
<td>0.136</td>
<td>0.0483</td>
<td>2.81</td>
</tr>
<tr>
<td>$\beta_{PaidFare}$</td>
<td>-0.936</td>
<td>0.413</td>
<td>-2.26</td>
</tr>
<tr>
<td>$\beta_{REG}$</td>
<td>1.19</td>
<td>0.501</td>
<td>2.37</td>
</tr>
</tbody>
</table>

- **Number of observations**: 1,655
- **Log-Likelihood with respect to zero**: -1892.648
- **Final Log-Likelihood**: -1052.830

| $\rho^2$ | 0.444 |
| $\hat{\rho}^2$ | 0.439 |
## Model Estimation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient (β)</th>
<th>$\beta / \beta_{IVT}$</th>
<th>$\beta / \beta_{Wait}$</th>
<th>$\beta / \beta_{walk}$</th>
<th>$\beta / \beta_{walk.freq}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVT</td>
<td>-0.0733</td>
<td>1.00</td>
<td>0.35</td>
<td>0.10</td>
<td>0.14</td>
</tr>
<tr>
<td>IWT</td>
<td>-0.208</td>
<td>2.84</td>
<td>1.00</td>
<td>0.27</td>
<td>0.39</td>
</tr>
<tr>
<td>NTR</td>
<td>-5.92</td>
<td>80.76</td>
<td>28.46</td>
<td>7.72</td>
<td>11.02</td>
</tr>
<tr>
<td>PAID.FARE</td>
<td>-0.936</td>
<td>12.77</td>
<td>4.50</td>
<td>1.22</td>
<td>1.74</td>
</tr>
<tr>
<td>REG</td>
<td>1.19</td>
<td>-16.23</td>
<td>-5.72</td>
<td>-1.55</td>
<td>-2.22</td>
</tr>
<tr>
<td>WALK</td>
<td>-0.767</td>
<td>10.46</td>
<td>3.69</td>
<td>1.00</td>
<td>1.43</td>
</tr>
<tr>
<td>WALK.FREQ</td>
<td>-0.537</td>
<td>7.33</td>
<td>2.58</td>
<td>0.70</td>
<td>1.00</td>
</tr>
<tr>
<td>VOT</td>
<td></td>
<td>$$4.70$</td>
<td>$$13.33$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Application

- GTFS
- Access/Egress/Transfer links
  - Access: 0.5 mile
  - Transfer: 0.25 mile
- CAMPO TAZ Data
- CAMPO OD Matrix
- Departure Time Profile
- Individual Passengers
- Transit Network
- Assignment Model (FAST-TrIPs)
  - Passenger Flow
  - Passenger Trajectory

Model Estimated in This Study

Route Choice Parameters
Application

- Austin regional network
- 78 express and local routes
- 2,700 transit stops
- Modeled AM and PM peak
- 80,000+ passengers
Application

- Walking Time: 33,038 (54%)
- Waiting Time: 14,292 (24%)
- In-Vehicle Time: 13,356 (22%)

Total: 60k Passenger-Hours

- Direct: 41.7%
- 1 Transfer: 52.3%
- 2 or More Transfers: 6.0%

Total: 122K Unlinked Trips
Application

<table>
<thead>
<tr>
<th>Route</th>
<th>Observed</th>
<th>Estimated</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14000</td>
<td>13000</td>
</tr>
<tr>
<td>2</td>
<td>12000</td>
<td>11000</td>
</tr>
<tr>
<td>4</td>
<td>10000</td>
<td>9000</td>
</tr>
<tr>
<td>7</td>
<td>8000</td>
<td>7000</td>
</tr>
<tr>
<td>10</td>
<td>6000</td>
<td>5000</td>
</tr>
<tr>
<td>20</td>
<td>4000</td>
<td>3000</td>
</tr>
<tr>
<td>37</td>
<td>3000</td>
<td>2000</td>
</tr>
<tr>
<td>101</td>
<td>2000</td>
<td>1000</td>
</tr>
<tr>
<td>311</td>
<td>1000</td>
<td>5000</td>
</tr>
<tr>
<td>320</td>
<td>800</td>
<td>400</td>
</tr>
<tr>
<td>325</td>
<td>600</td>
<td>300</td>
</tr>
<tr>
<td>331</td>
<td>400</td>
<td>200</td>
</tr>
<tr>
<td>333</td>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>

Daily Ridership vs Route
Conclusions

• A route choice model can enhance the assignment model
• Transfer has a high disutility for transit users in Austin, TX
• Walking has higher disutility for infrequent users
• Fare (Value of Time) has significant effect on passengers’ decision making in transit networks
Conclusions

• Possible Future Work:
  – Validation of the results
  – Incorporating more variables (e.g. reliability)
  – Testing more complex models

• Advanced tool for transit data analysis and visualization, and calibration of the assignment model
Questions?

Thank you!

Alireza Khani
akhani@utexas.edu