Modeling the Departure-Time Choice for Home-to-Work Commute Travel

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Layout of the Presentation

- Motivations
- Literature
- Our Approach
- Data
- Methodology
- Empirical results
- Summary
Motivations

- **Commute Trends**
  - Travel Times: 1980 – 21.7 min, 1990 – 22.4 min, 2000 - 25.5 min
  - 35 million SOV added
  - Peak spreading (6 - 9 AM), 67 % 1990 to 64 % 2000

- **Life Style Trends**
  - Flexible work schedules, telecommuting, trip chaining, …

- **Need models for accurately predicting time-varying travel-demand patterns for a future year**
  - Models should be sensitive to life-style trends

- **Need models for evaluating congestion-mitigation policy actions (e.g. Dynamic pricing)**
  - Models should be at a fine temporal resolution
1. **Modeling methodology**
   - Predominantly MNL or variants – requires discretization of time

2. **Temporal resolution of choice alternatives**
   - Few aggregate alternatives spanning entire day
   - Finer resolution (5 -15 min) spanning specific time-of-day period (such as morning)

3. **Temporal resolution of transportation system characteristics**
   - Peak and off-peak skims (+ Interpolations)
   - Field studies
   - Regression analysis from survey data

4. **Survey data**
   - Revealed preference: preferred work start times unknown / assumed
   - Stated preference: preferred work start times known
Our Approach

1. Modeling methodology
   • Hazard duration structure – treats time as a continuous variable

2. Temporal resolution of choice alternatives
   • Continuous time

3. Temporal resolution of transportation system characteristics
   • Regression analysis from survey data

4. Survey data
   • Revealed preference data – preferred work start times taken as a latent variable

5. Explanatory Factors
   • Socio-economic characteristics, employment characteristics, residential and work location, day-of-the week, time-varying transportation system characteristics
Data

- Dataset for Inter-zonal travel time model
  - 68801 records
  - Day – 96, 15 min intervals
  - Dependent is door–to–door travel time, skims centroid-centroid

- Dataset for Commute timing model – flexible workers
  - 4661 commute journeys, 3162 people and 2894 households
  - Distribution of departure times from the data

- Dataset for Commute timing model – fixed schedule
  - 4211 commute journeys, 2750 people and 2452 households
  - Distribution of departure times from the data
Methodology – Travel time models

- Inter zonal travel time - Linear regression
- X – trip distance and land use characteristics
- In total 10 regression models
  - Fully segment - 4 distance 0-5, 5-15, 15-30, >30
  - Further segment – origin and destination type
  - Coefficients difficult to interpret - Resulting graphs

\[
\frac{T_{ijt}}{FF_{ij}} = \lambda_0 + \alpha X + \beta_1 \sin\left(\frac{\pi t}{12}\right) + \beta_2 \sin^2\left(\frac{\pi t}{12}\right) + \ldots + \beta_n \sin^n\left(\frac{\pi t}{12}\right) \\
+ \gamma_1 \cos\left(\frac{\pi t}{12}\right) + \gamma_2 \cos^2\left(\frac{\pi t}{12}\right) + \ldots + \gamma_n \cos^n\left(\frac{\pi t}{12}\right)
\]
Methodology – Commute timing models

- **Proportional hazard model**

\[
\lambda(u) = \lambda_0(u) \exp \left( \beta X + \gamma Z(u) \right) w
\]

\[
S(a_p) = \exp \left( -\int_{-\infty}^{a_p} \lambda(u) \, du \right)
\]

\[
\text{Prob}[t = p] \mid w = \text{Prob}[a_{p-1} < u < a_p] \mid w
\]

\[
= S(a_{p-1}) \mid w - S(a_p) \mid w
\]

\[
\text{Prob}[t = p] = \left[ 1 + \sigma^2 \left\{ \sum_{j=0}^{p-1} \Delta_j \exp \left( \delta_j + \beta X + \gamma Z_j \right) \right\} \right]^{-\sigma^2}
\]

\[
- \left[ 1 + \sigma^2 \left\{ \sum_{j=0}^{p} \Delta_j \exp \left( \delta_j + \beta X + \gamma Z_j \right) \right\} \right]^{-\sigma^2}
\]

\[
\text{prob}[t = p] = \sum \text{prob}[t = p \mid WST] f(WST)
\]

**Fixed Schedule Workers**
## Empirical results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Flexible Schedule</th>
<th>Fixed Schedule</th>
<th>Variable</th>
<th>Flexible Schedule</th>
<th>Fixed Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual and Household Socio-Economic Characteristics</strong></td>
<td></td>
<td></td>
<td><strong>Location and Commute Distance Characteristic</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>+ve</td>
<td>+ve</td>
<td>Home location is Suburban</td>
<td>+ve</td>
<td>NA</td>
</tr>
<tr>
<td>Male</td>
<td>Insignificant</td>
<td>+ve</td>
<td>Work location is CBD</td>
<td>+ve</td>
<td>NA</td>
</tr>
<tr>
<td>Number of kids in the household</td>
<td></td>
<td>+ve</td>
<td>Commute Distance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household Income</td>
<td>-ve</td>
<td>Insignificant</td>
<td>0 - 5 miles (Base)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household structure</td>
<td></td>
<td></td>
<td>5 - 15 miles</td>
<td>+ve</td>
<td>+ve</td>
</tr>
<tr>
<td>Nuclear, Single parent, Other (Base)</td>
<td><img src="image" alt="" /></td>
<td>NA</td>
<td>15 - 30 miles</td>
<td>+ve</td>
<td>+ve</td>
</tr>
<tr>
<td>Single person household</td>
<td>-ve</td>
<td>NA</td>
<td>30 - 50 miles</td>
<td>+ve</td>
<td>+ve</td>
</tr>
<tr>
<td>Couple married or unmarried</td>
<td>-ve</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of a non-flexible worker in the HH</td>
<td>+ve</td>
<td>Insignificant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Individual Employment characteristics</strong></td>
<td></td>
<td></td>
<td><strong>Time Varying Transportation system characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work duration</td>
<td>+ve</td>
<td>+ve</td>
<td>Travel time</td>
<td>+ve</td>
<td>+ve</td>
</tr>
<tr>
<td>Work frequency less than 4 days a week</td>
<td>+ve</td>
<td>+ve</td>
<td>% Increase in travel time in the next 15 min</td>
<td>-ve</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Day of the Week</strong></td>
<td></td>
<td></td>
<td>Schedule Delay on the early side (min)</td>
<td>NA</td>
<td>-ve</td>
</tr>
<tr>
<td>Day is Friday</td>
<td>+ve</td>
<td>Insignificant</td>
<td>Schedule Delay on the late side (min)</td>
<td>NA</td>
<td>+ve</td>
</tr>
</tbody>
</table>
Summary

- **Disaggregate** departure time choice of full time workers—**Continuous** time scale
  - Hazard duration framework – Departure choice models
  - Flexible & Fixed schedule workers

- Incorporated effects of **varying travel times** by time-of-day @ 15 min resolution (**Significant**)
  - **Trigonometric regression** – Travel time models

- **Also** captures the impacts of
  - Individual and household socio-economic
  - Individual employment characteristics
  - Location and commute distance characteristics
  - Time varying transportation system characteristics
Thank you...

Questions ??
Distribution of departure time by TOD – flexible schedule workers
Distribution of departure time by TOD – fixed schedule workers
Travel time variation – Illustrative graphs