Riding More Frequently: Disaggregate Ridership Elasticity Estimation for Chicago’s Bus Network

Charlotte Frei
Hani S. Mahmassani
Northwestern University Transportation Center
Source: flickr user clapifyoulikedinosaurs
Objectives

- Purpose of Elasticity:
  \[
  \frac{\partial \ln E(Y \mid X)}{\partial \ln X} \approx \frac{\%\Delta Y}{\%\Delta X}
  \]

- Note direct and indirect influences on transit ridership

- Comparative magnitude of external and indirect influences
Estimates of Transit Elasticities

Typical analysis is macro-level: population, employment and zonal travel times

Macro-level analyses can not capture the shift in supply and demand curves from population and employment changes

How to capture parcel and block-level effects?
Agencies manage a relatively small portion of factors that influence transit use.

- Land use density and mix, parking prices and supply, income, car ownership, employment and population characteristics.
- Transit fare, service frequency and span, comfort, cleanliness, (speed and reliability).
- (Speed and reliability), dwell time, convenience, walk quality, attitudes, safety, security, gasoline prices as influence on transit fare.
Data

• Stop-level boardings, alightings and frequency of CTA buses in 30-minute intervals

• CMAP’s 2005 Land Use Inventory

• Crimes from City of Chicago data portal

• Indicator for presence of CTA rail, Metra, or Pace

• Population and employment data by CMAP subzone

• Median income by census tract
Walk Quality

Jackson Boulevard and State Street
Source: Chicago Tribune, May 31, 2013
… vs. Walk Score

“amenities within .25 miles receive maximum points, and no points are awarded for amenities further than one mile”

0-24: Car-Dependent, Almost all errands require a car;
25-49: Car-Dependent, A few amenities within walking distance;
50-69: Somewhat Walkable, Some amenities within walking distance;
70-89: Very Walkable, most errands can be accomplished on foot;
90-100: “Walker’s Paradise”, daily errands do not require a car.
\[
\ln(b_{t,r,s}^y) = \alpha + \beta_h \ln(h_{t,r,s}^y) + \beta_e \ln(b_{t,r,s}^{y-1}) + \beta_{\bar{\sigma}} \ln(\bar{\sigma}_s) + \sum_{\phi \in \Phi} \sum_{z \in Z} \beta_\phi \ln(Y_{\phi,z}) X^z_s \\
+ \left[ \sum_{a \in A} \lambda_a X^a_s \right] + \left[ \sum_{\mu \in \mathcal{M}} \lambda_\mu X^\mu_{t,s} \right] + \left[ \sum_{u \in \mathcal{U}} \lambda_u X^u_t \right] + \varepsilon^y_{t,r,s}
\]

- Headway
- Ridership in previous time period
- Walk score
- Socio-demographics
- Land use
- Presence of other modes
- Time periods
## Results

<table>
<thead>
<tr>
<th>1% change in …</th>
<th>Yields -- % change in ridership</th>
<th>Sig. Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Past ridership (dynamic term)</td>
<td>--</td>
<td>.001</td>
</tr>
<tr>
<td>Frequency of service</td>
<td>+0.26</td>
<td>.001</td>
</tr>
<tr>
<td>Walk Score</td>
<td>+ 0.20 - 0.25</td>
<td>.001</td>
</tr>
<tr>
<td>Time of Day</td>
<td>Varies</td>
<td>.001</td>
</tr>
<tr>
<td>Presence of CTA Rail/Metra</td>
<td>-/+</td>
<td>.001</td>
</tr>
<tr>
<td>Income</td>
<td>- 0.23 – -0.36</td>
<td>.001</td>
</tr>
<tr>
<td>Crime</td>
<td>- 0.17 – -0.35</td>
<td>.001</td>
</tr>
<tr>
<td>Non-retail employment</td>
<td>- 0.01</td>
<td>.001</td>
</tr>
<tr>
<td>Land Use</td>
<td>+ mixed use, medical, educ</td>
<td>.01-.05</td>
</tr>
<tr>
<td>Household vehicles</td>
<td>- 0.002</td>
<td>.01-.05</td>
</tr>
<tr>
<td>Population and retail employment</td>
<td>- for 18+ population, + otherwise</td>
<td>.05</td>
</tr>
</tbody>
</table>
Land Use

![Diagram of land use patterns with various symbols representing different types of land use such as commercial, education, industrial, medical, mixed use, no parking, mixed use with parking, recreational, and residential. The x-axis represents half-hour intervals, and the y-axis represents median medium-term arc elasticity.]
Results

Studies using aggregate data overestimate the effect of frequency on network ridership.

Sensitivity of peak and off-peak ridership not as extreme as suggested.
Conclusions

Unique attributes of service areas should be considered

Transit provision may supplement school buses and healthcare delivery for persons without cars

Distance to amenities is more important than population density or mixed land use alone → context of TODs
Implications for service delivery

Setting frequency to maximize ridership, subject to constraints and anticipated changes in demand.
Limitations

• Influences on other modes, like parking and fuel costs, should be included

• Attributes that enhance service- like new rail cars or buses, bus tracker- can influence attitudes and perceived service quality

• Need to examine over longer time horizon to capture responses to fare and fuel costs simultaneously

• Complementary/competing modes
Further Reading

On this work, TRB compendium of papers:

13-3413
13-3267
13-5252

On Chicago's neighborhood effects:  

Great American City by Robert J. Sampson

On transit elasticity


Thank you!

- Omer Verbas, NUTC
- Scott Wainwright, Alex Cui, Jon Czerwinski, CTA
- Greg Newmark, RTA