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

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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

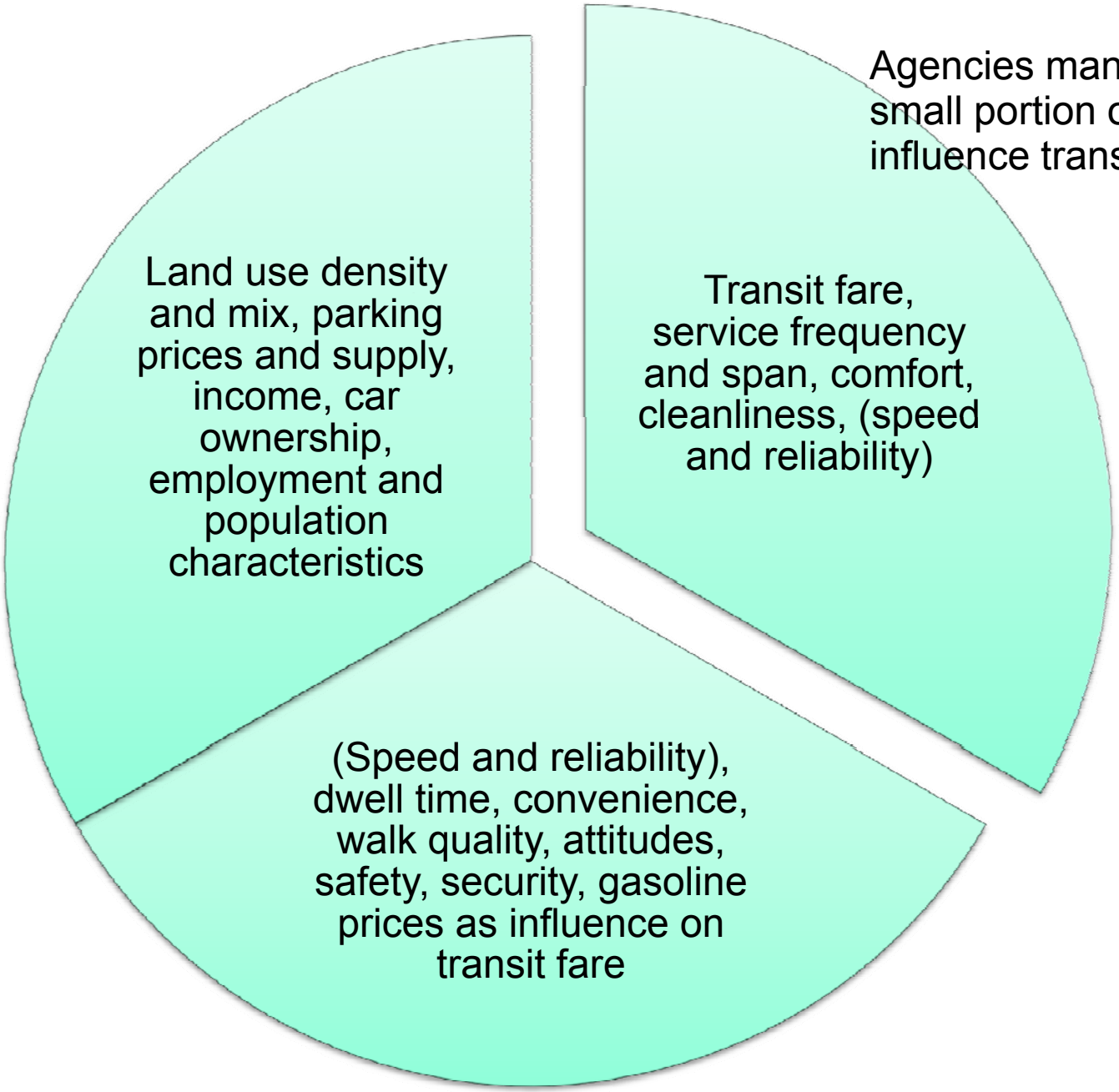
Estimates of Transit Elasticities

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

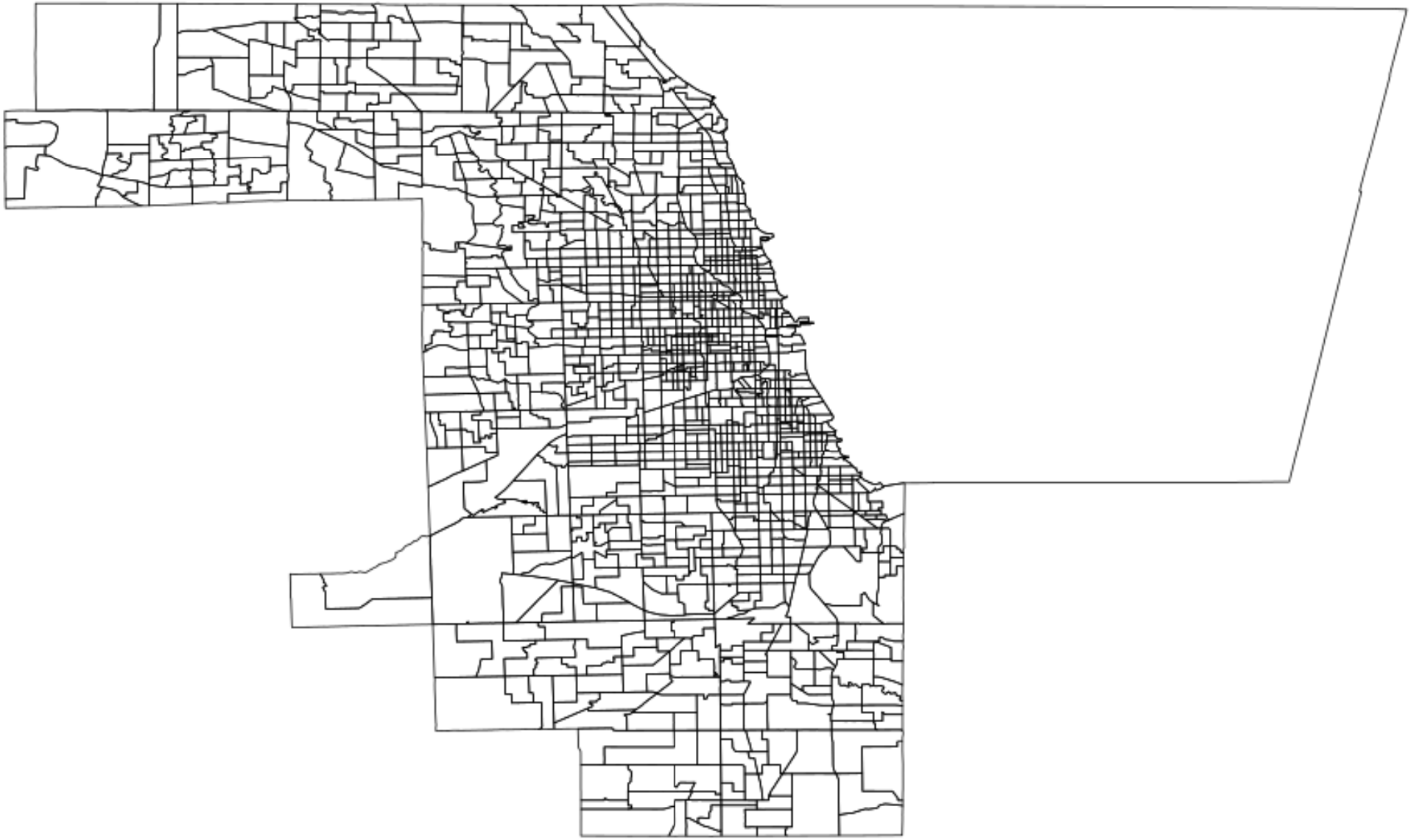
How to capture parcel and block-level effects?

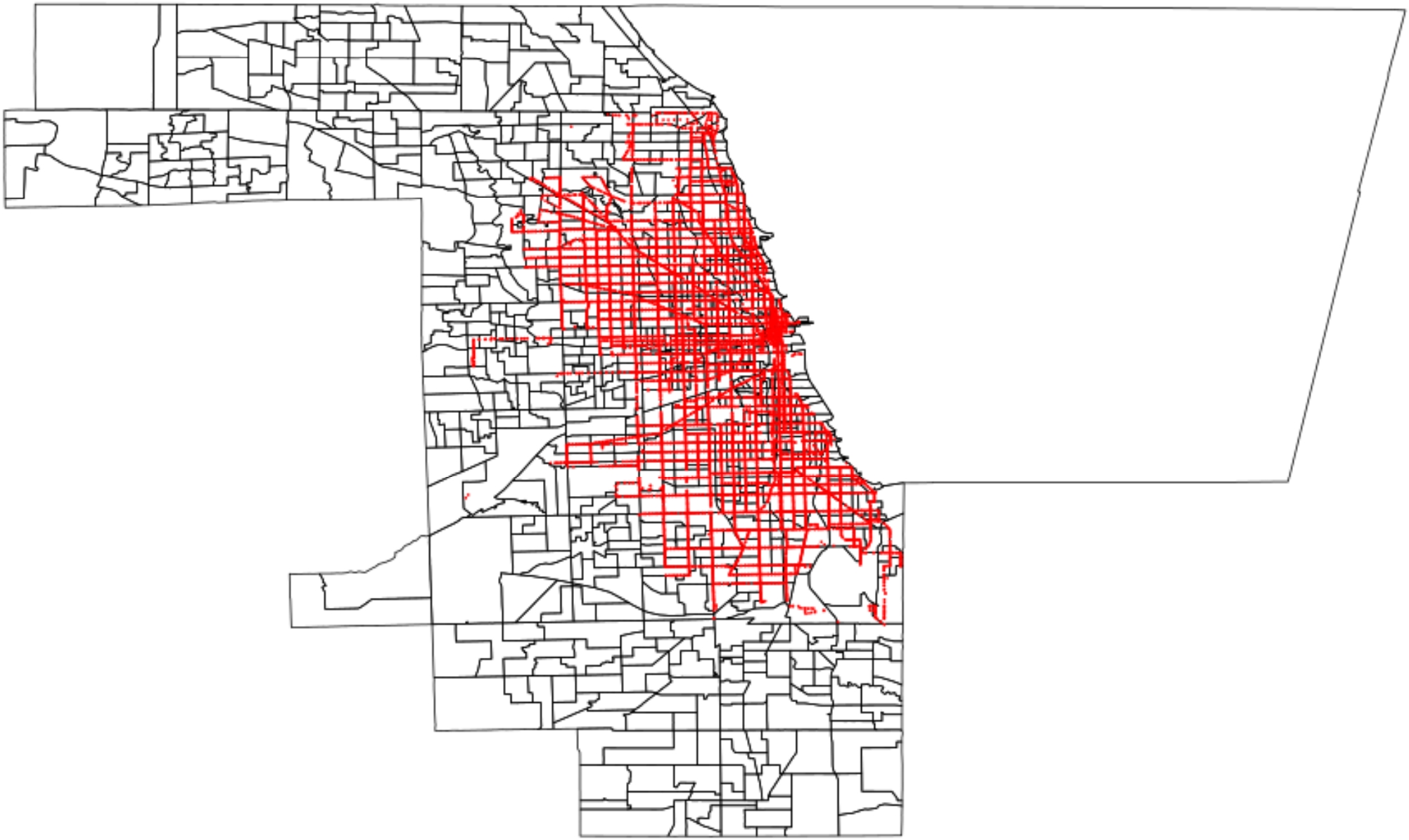
Agencies manage a relatively small portion of factors that influence transit use



Data

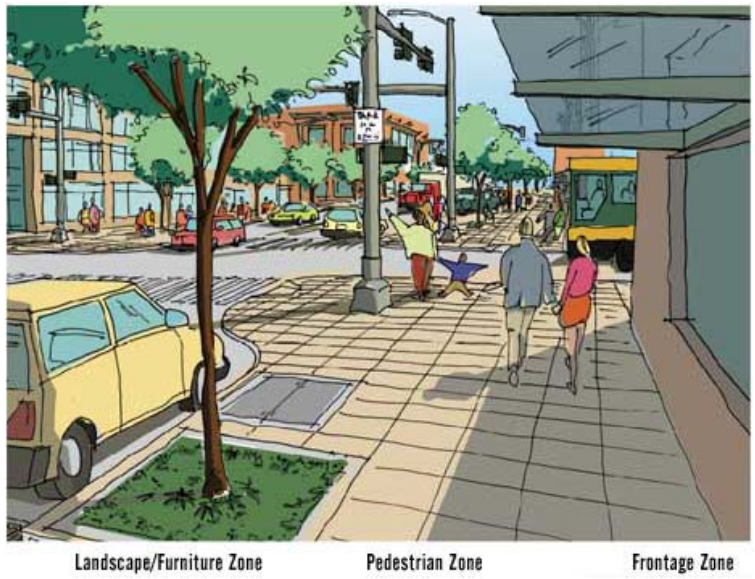
- Stop-level boardings, alightings and frequency of CTA buses in 30-minute intervals
- CMAP's 2005 Land Use Inventory
- Crimes from City of Chicago data portal
- Indicator for presence of CTA rail, Metra, or Pace
- Population and employment data by CMAP subzone
- Median income by census tract

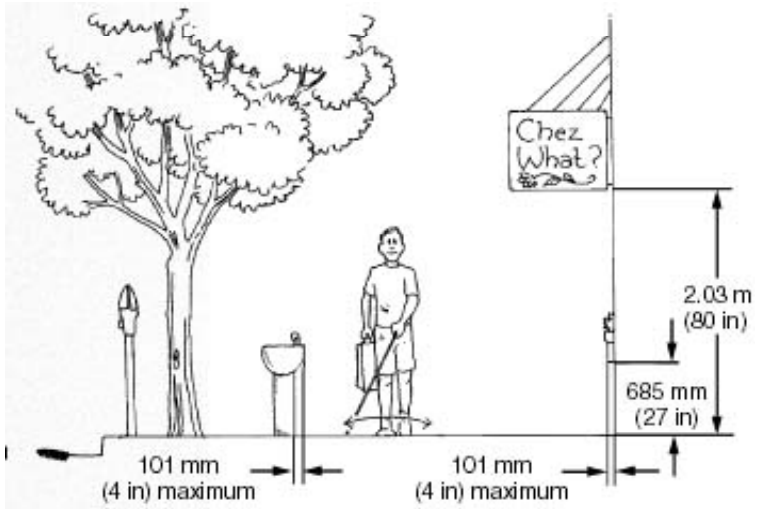




Walk Quality

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.

$$\ln\left(b_{t,r,s}^{v}\right)=\alpha+\beta_h\ln\left(h_{t,r,s}^{v}\right)+\beta_e\ln\left(b_{t,r,s}^{v-1}\right)+\beta_{\varpi}\ln\left(\varpi_s\right)+\left[\sum_{\varphi\in\Phi}\sum_{z\in Z}\beta_{\varphi}\ln\left(Y_{\varphi,z}\right)X_s^z\right]$$

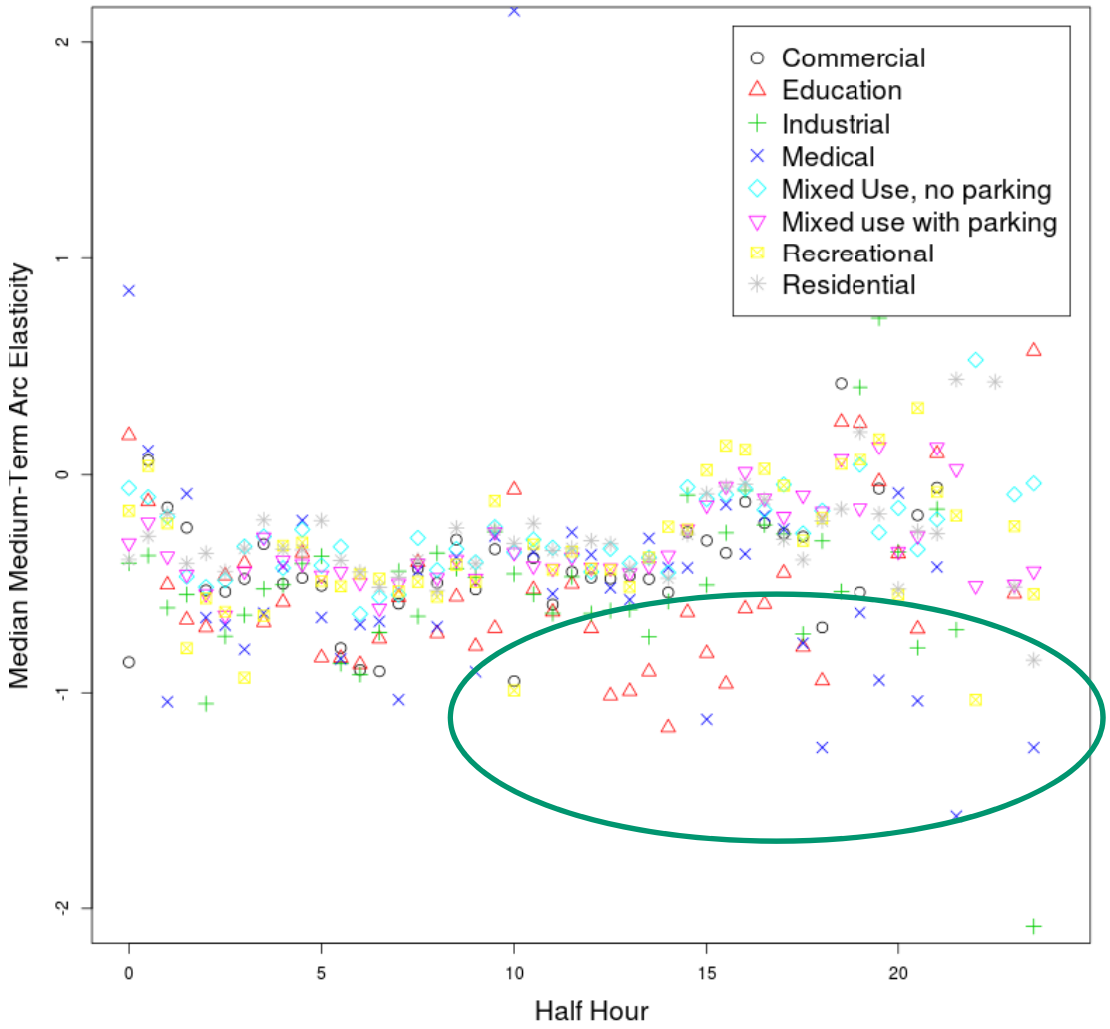
$$+\left[\sum_{a\in A}\lambda_a X_s^a\right]+\left[\sum_{\mu\in \mathrm{M}}\lambda_\mu X_{t,s}^{\mu}\right]+\left[\sum_{u\in U}\lambda_u X_t^u\right]+\varepsilon_{t,r,s}^{v}$$

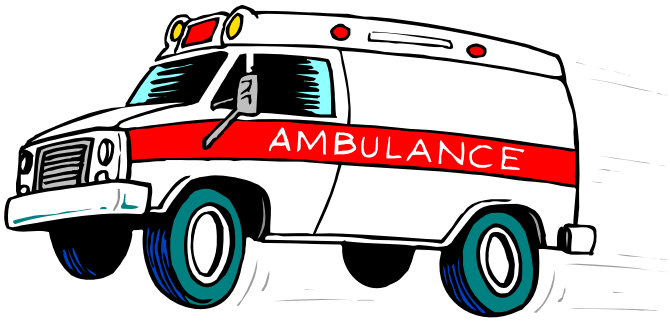
- Headway
- Ridership in previous time period
- Walk score
- Socio-demographics
- Land use
- Presence of other modes
- Time periods

Results

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

Land Use


Commercial
Education
Industrial
Medical
Mixed Use, no parking
Mixed use with parking
Recreational
Residential
Median Medium-Term Arc Elasticity
Half Hour
2
1
0
-1
-2
0
5
10
15
20


AMBULANCE

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

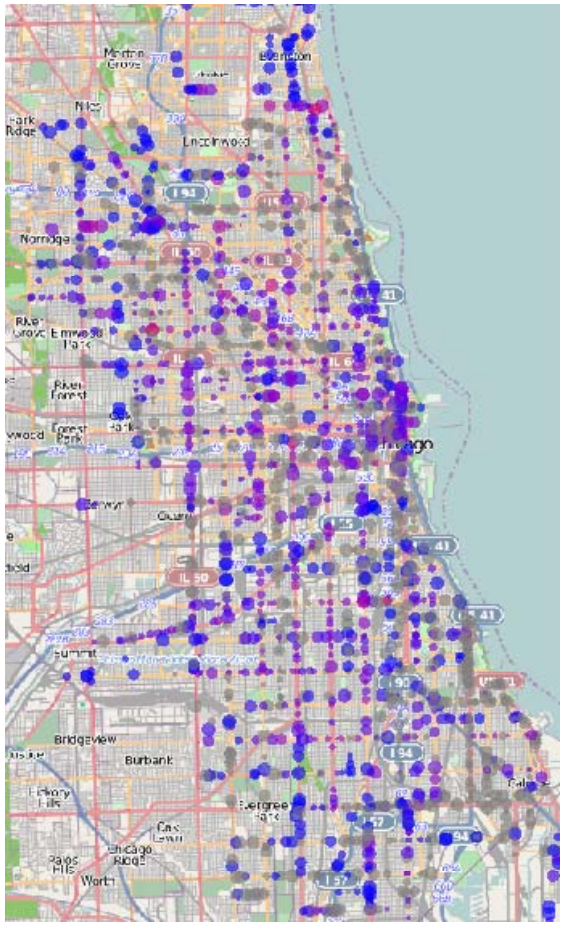
Unique attributes of service areas should be considered

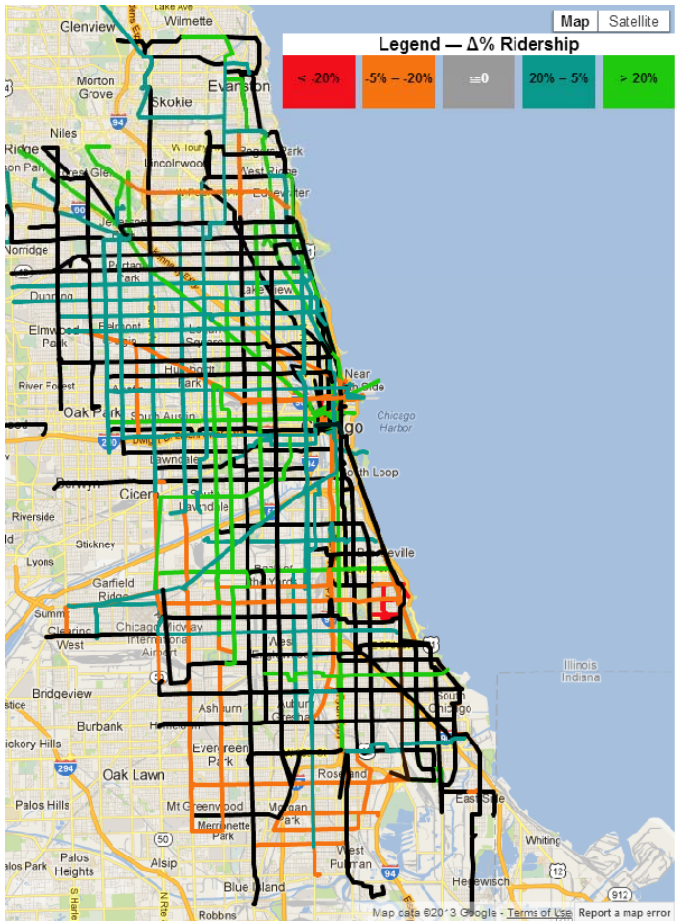
Transit provision may supplement school buses and healthcare delivery for persons without cars

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

Litman, T. Transit Price Elasticities and Cross-Elasticities. *Journal of Public Transportation*, Vol. 7, No. 2, 2004, pp 37-58.

Chen, C., D. Varley, and J. Chen. What affects Transit Ridership? A Dynamic Analysis Involving Multiple Factors, Lags, and Asymmetric Behavior. *Urban Studies*, Vol. 49, No. 9, 2011, pp. 1893-1908.

Taylor, B.D., D. Miller, H. Iseki, and C. Fink. Nature and/or Nurture? Analyzing the Determinants of Transit Ridership Across US Urbanized Areas. *Transportation Research Part A*, Vol. 43, 2009, pp. 60-77.

Thompson, G., J. Brown, T. Bhattacharya, and M. Jarozynski. *Understanding Transit Ridership Demand for a Multi-Destination, Multimodal Transit Network in An American Metropolitan Area*. Report CA-MTI-12-1003. Mineta Transportation Institute, RITA, U.S. Department of Transportation, 2012. Available http://transweb.sjsu.edu/project/1003.html.

Thank you!

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- Greg Newmark, RTA