Enhancing Active Transportation Sensitivities of an Activity–Based Model

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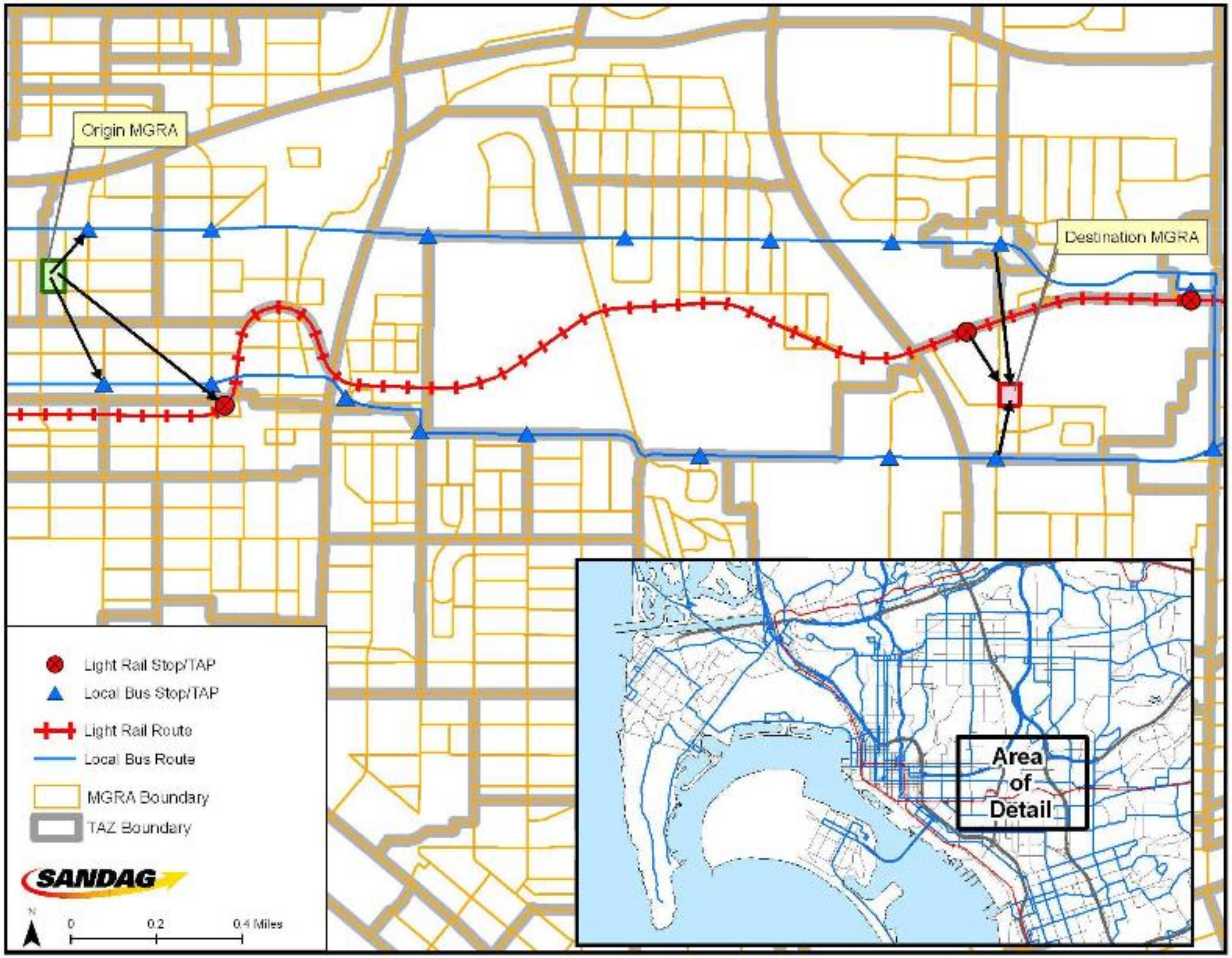
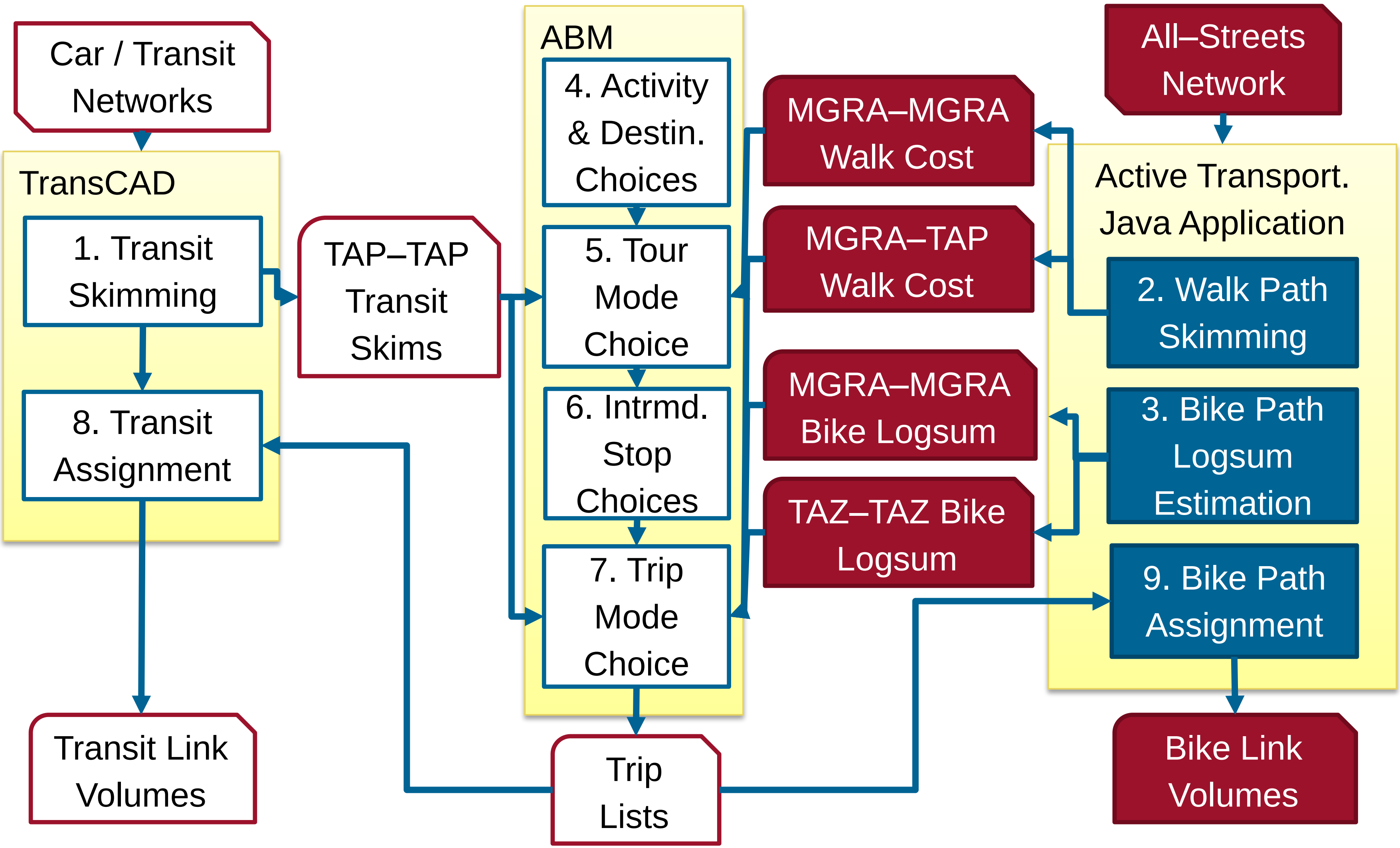
SANDAG plans $3 billion in grants for pedestrian and cycling improvements to 2050

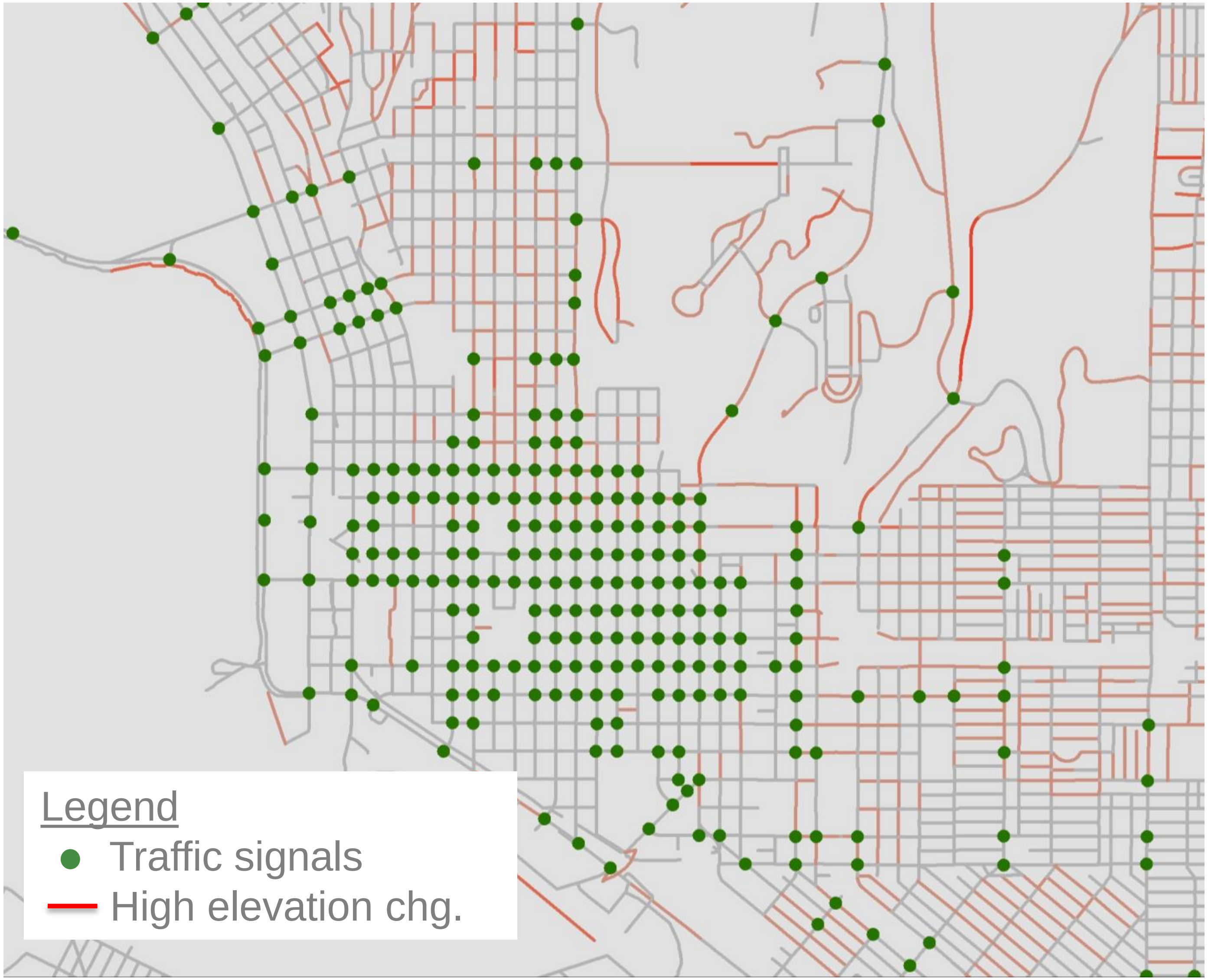
ABM had detailed spatial resolution, but walk & bike not sensitive to network attributes



Active Transportation Enhancements

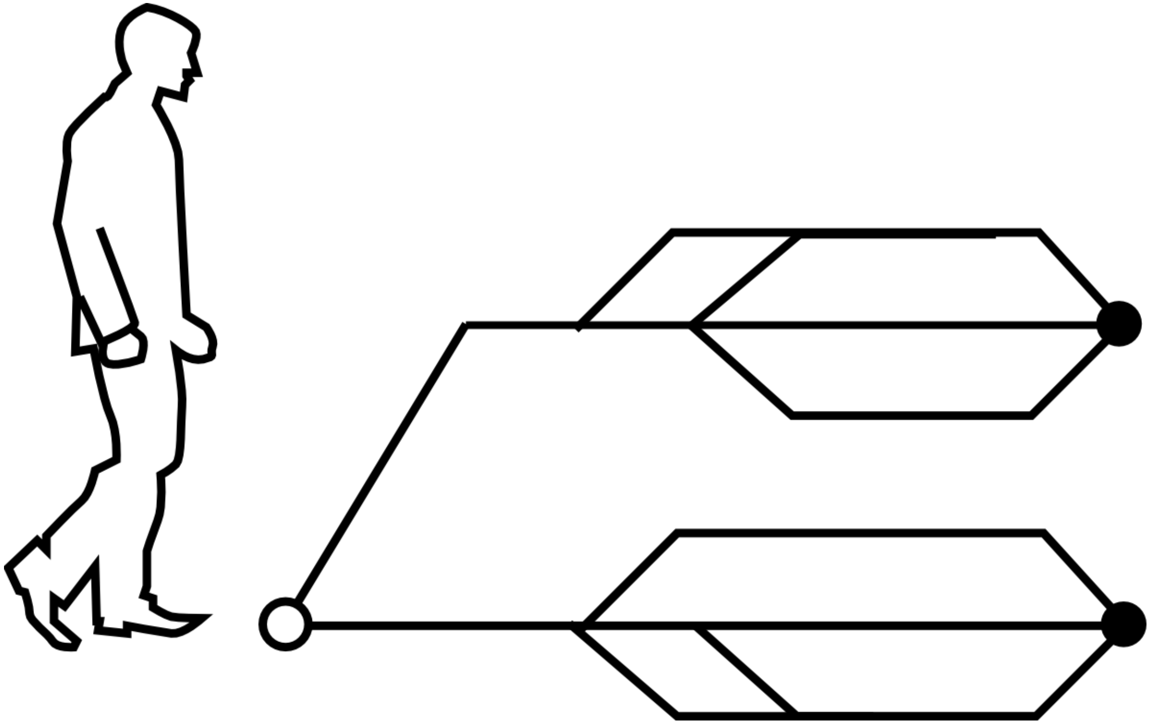


New Active Transport Network



Cycling Route Choice Utility Parameters

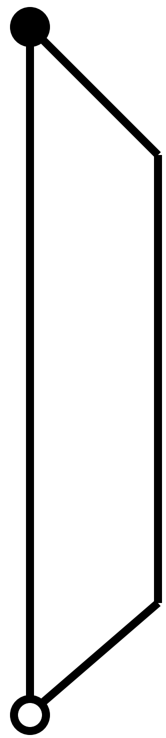
Variable	Coef.	Source
Distance on ordinary streets (mi.)	–0.858	Monterey
Distance on class I bike paths	–0.248	Portland
Distance on class II bike lanes	–0.544	Monterey
Distance on class III bike routes	–0.773	Monterey
Distance on arterials without bike lanes	–1.908	Monterey
Distance on “cycle tracks”	–0.424	–
Distance on “bike boulevards”	–0.343	Portland
Distance wrong way	–4.303	San Francisco
Elevation gain, cumulative, ignoring declines (ft.)	–0.010	San Francisco
Turns, total	–0.083	Portland
Traffic signals, excl. rights & thru junctions	–0.040	Portland
Un–signalized lefts from principal arterial	–0.360	Portland
Un–signalized lefts from minor arterial	–0.150	Portland
Un–signalized xing of & left onto principal arterial	–0.480	Portland
Un–signalized xing of & left onto minor arterial	–0.100	Portland
Log of path size	1.000	Constrained



How can we estimate consistent multi–path impedances?

What's wrong with single–path impedance?

Base

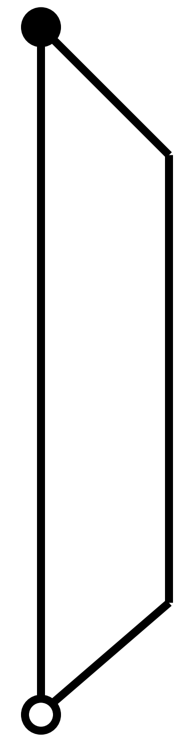


Path 1
Dist.: 1 mi.
Bike Lane: No
Utility: –0.86

Path 2
Dist.: 2 mi.
Bike Lane: No
Utility: –1.72

Max. Utility: –0.86

Build



Path 1
Dist.: 1 mi.
Bike Lane: No
Utility: –0.86

Path 2
Dist.: 2 mi.
Bike Lane: **Yes**
Utility**: –1.09**

Max. Utility: –0.86

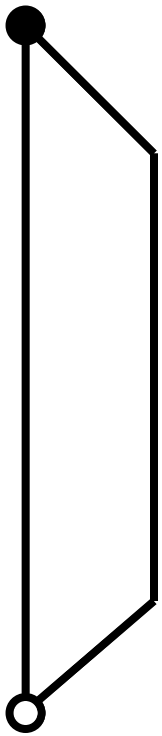
Difference: 0.00 ☹

How about expected utility?

Base

Path 1
Dist.: 1 mi.
Bike Lane: No
Utility: –0.86

Share: 70%



Path 2
Dist.: 2 mi.
Bike Lane: No
Utility: –1.72

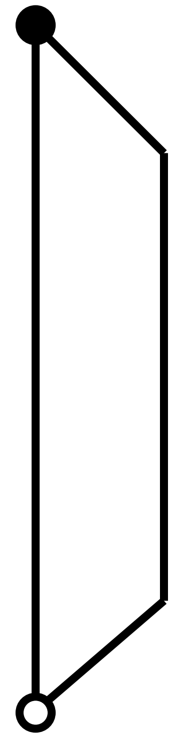
Share: 30%

Expected Utility: –1.12

Build

Path 1
Dist.: 1 mi.
Bike Lane: No
Utility: –0.86

Share: 55%



Path 2
Dist.: 2 mi.
Bike Lane: **Yes**
Utility**:** **–1.09**

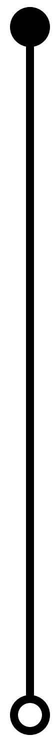
Share: 45%

Expected Utility: –0.96

Difference: +0.16 ☺

What if new alternatives appear?

Base

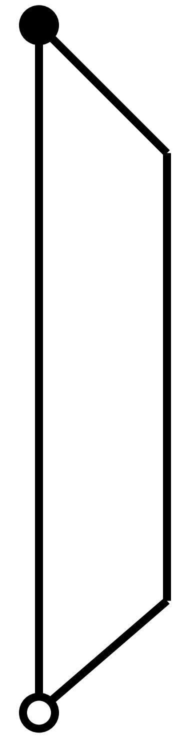


Path 1
Dist.: 1 mi.
Bike Lane: No
Utility: –0.86

Share: 100%

Expected Utility: –0.86

Build



Path 1
Dist.: 1 mi.
Bike Lane: No
Utility: –0.86

Share: 55%

Path 2
Dist.: 2 mi.
Bike Lane: **Yes**
Utility**: –1.09**

Share: 45%

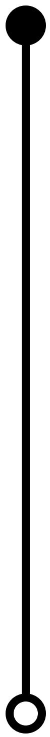
Expected Utility: –0.96

Difference: –0.10 ☹

How about the logsum?

Base

Path 1
Dist.: 1 mi.
Bike Lane: No
Utility: –0.86

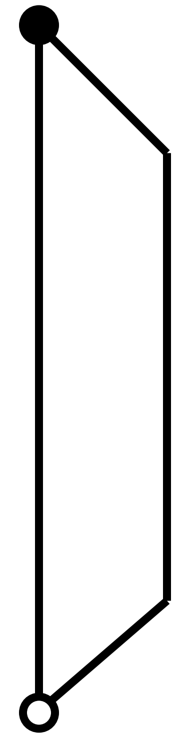


$$\log \sum_i e^{u_i}$$

Logsum: –0.86

Build

Path 1
Dist.: 1 mi.
Bike Lane: No
Utility: –0.86



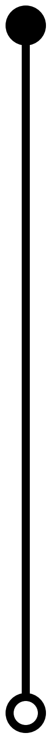
Path 2
Dist.: 2 mi.
Bike Lane: **Yes**
Utility**: –1.09**

Logsum: –0.28

Difference: +0.58 ☺

What if routes overlap?

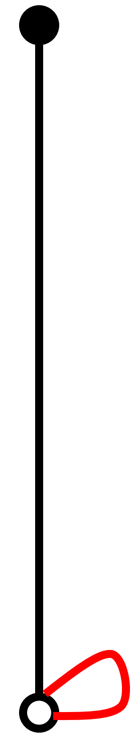
<u>Base</u>



Path 1
Dist.: 1 mi.
Bike Lane: No
Utility: –0.86

Logsum: –0.86

<u>Build</u>



Path 1
Dist.: 1 mi.
Bike Lane: No
Utility: –0.86

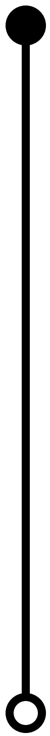
Path 2
Dist.: 1.0 mi.
Bike Lane: No
Utility: –0.86

Logsum: –0.16

Difference: +0.70 ☹

How about path size or cross–nested model?

Base

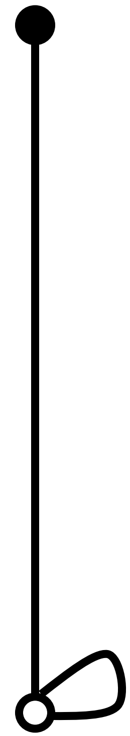


Path 1
Dist.: 1 mi.
Bike Lane: No
Path Size: 1.0
Utility: –0.86

$$PS_{in} = \sum_{a \in \Gamma_i} \frac{l_a}{L_i} \frac{1}{M_{an}}$$

Logsum: –0.86

Build



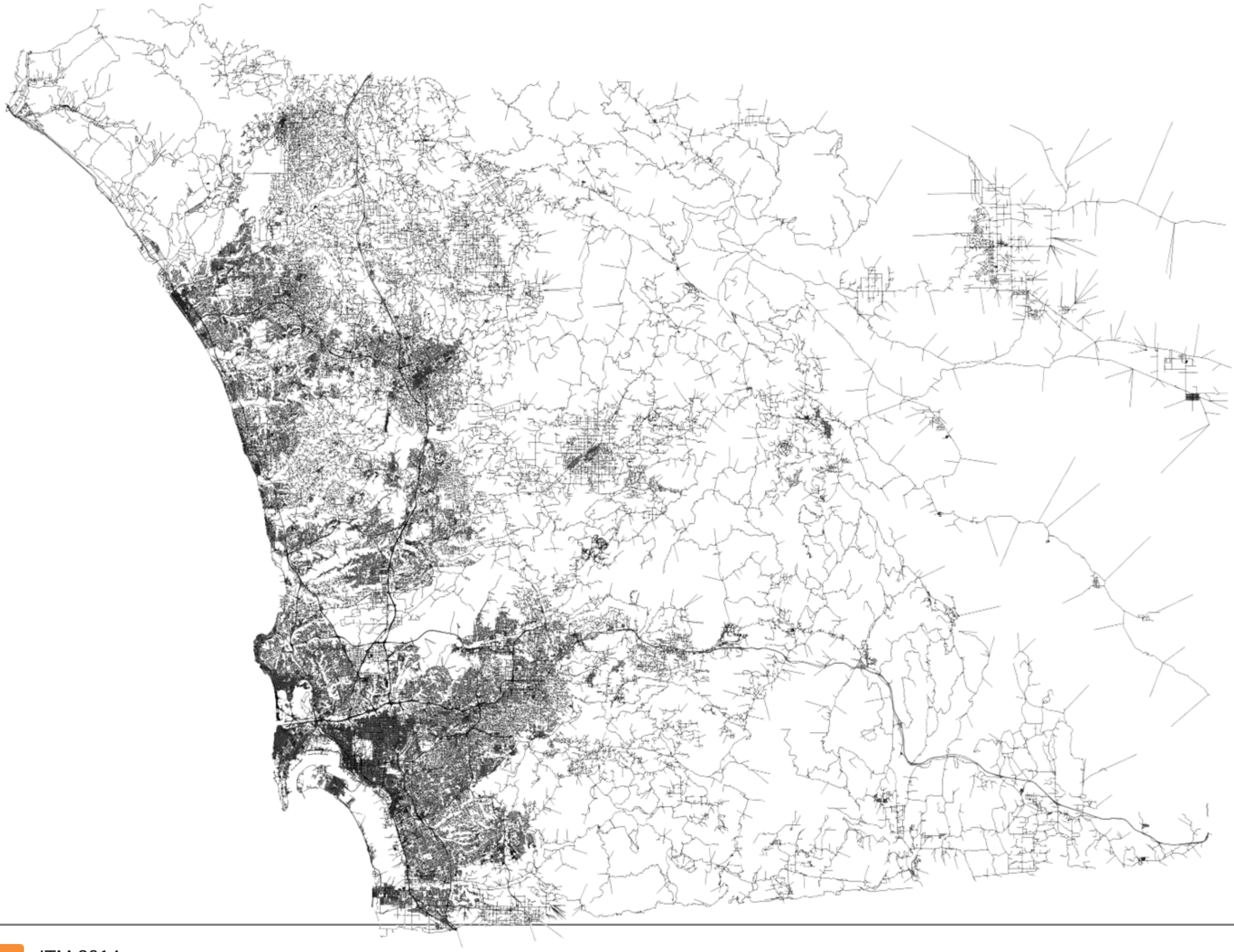
Path 1
Dist.: 1 mi.
Bike Lane: No
Path Size: 0.5
Utility: –0.86

Path 2
Dist.: 1.0 mi.
Bike Lane: No
Path Size: 0.5
Utility: –0.86

Logsum: –0.86

Difference: 0.00 ☺

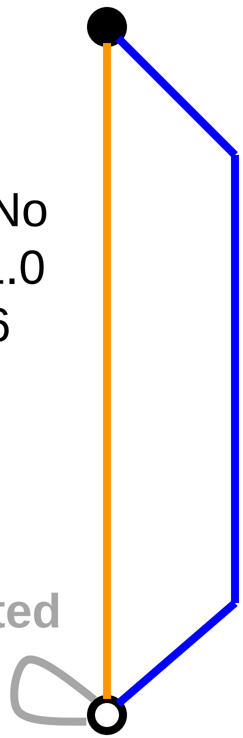
What if paths cannot be enumerated?



Can we control choice set size?

Base

Path 1
Dist.: 1 mi.
Bike Lane: No
Path Size: 1.0
Utility: –0.86



Path 2
Dist.: 2 mi.
Bike Lane: Yes
Path Size: 1.0
Utility: –1.09

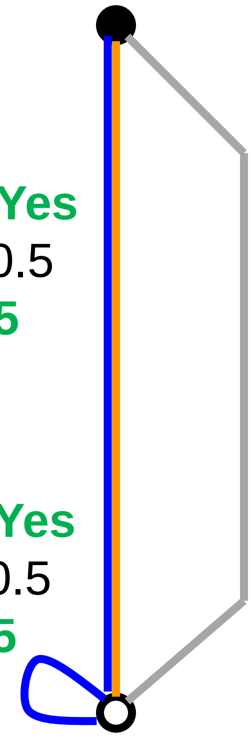
Not Generated

Logsum: –0.27

Build

Path 1
Dist.: 1 mi.
Bike Lane: **Yes**
Path Size: 0.5
Utility: **–0.55**

Path 2
Dist.: 1 mi.
Bike Lane: **Yes**
Path Size: 0.5
Utility: **–0.55**

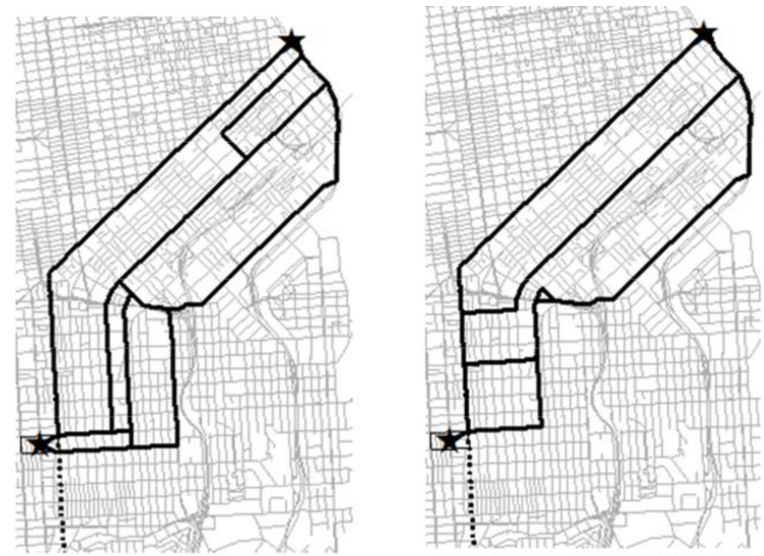


Not Generated

Logsum: –0.55

Difference: –0.28 ☹

How about with path size link penalty?



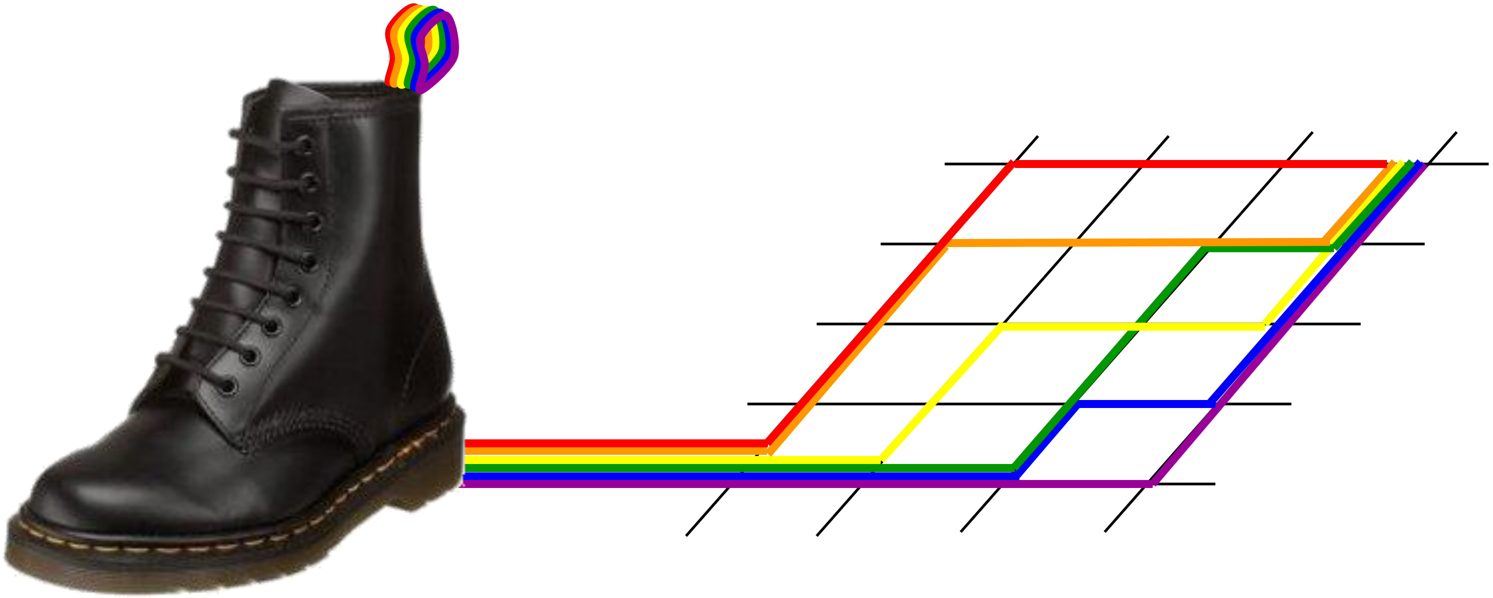
Base Build Base Build

Stochastic Sampling Path Size Link Penalty

Nassir et al. (2014), "A Choice Set Generation Algorithm Suitable for Measuring Route Choice Accessibility", 93rd TRB Annual Meeting.

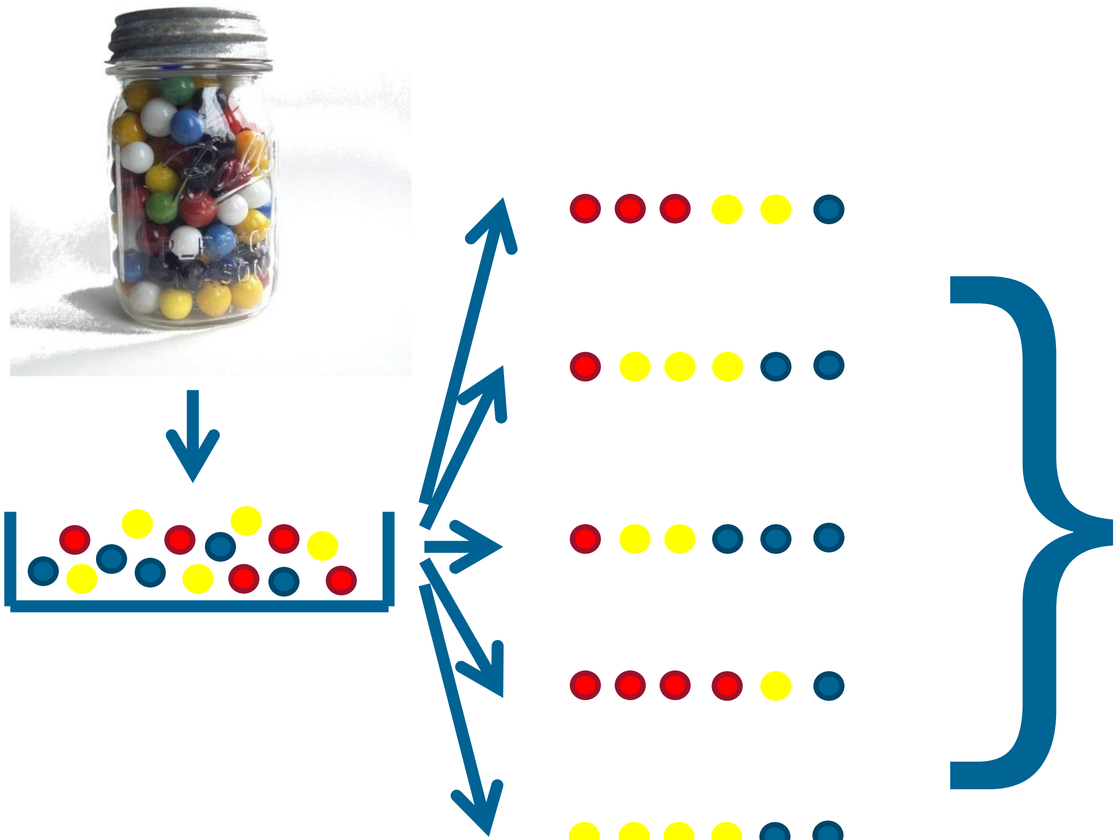
Run time is quadratic in zones.

1000 zones on 4 processors requires a week!



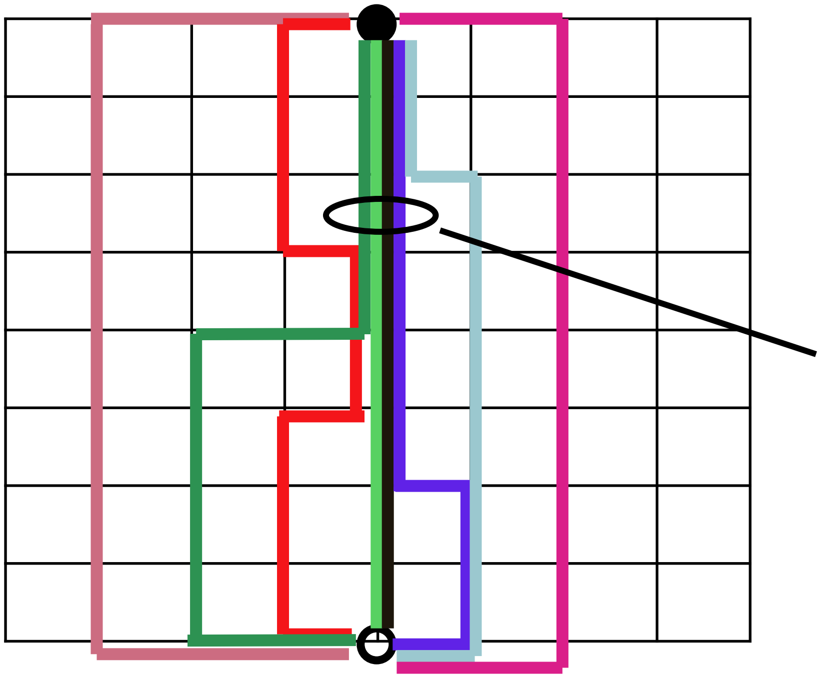
BootRouting

“Bootstrapping” approximates the sampling distribution of a statistic by resampling observations from a given sample set



$$SE\left(\hat{\mu}(\cdot)\right) = ?$$

BootRouting approximates sampling probabilities in stochastic path generation by repeatedly sampling overlapping routes



As $N \to \infty$, the proportion N_a/N of paths using link a converges to the probability of sampling a path that uses the link, $P(a)$.

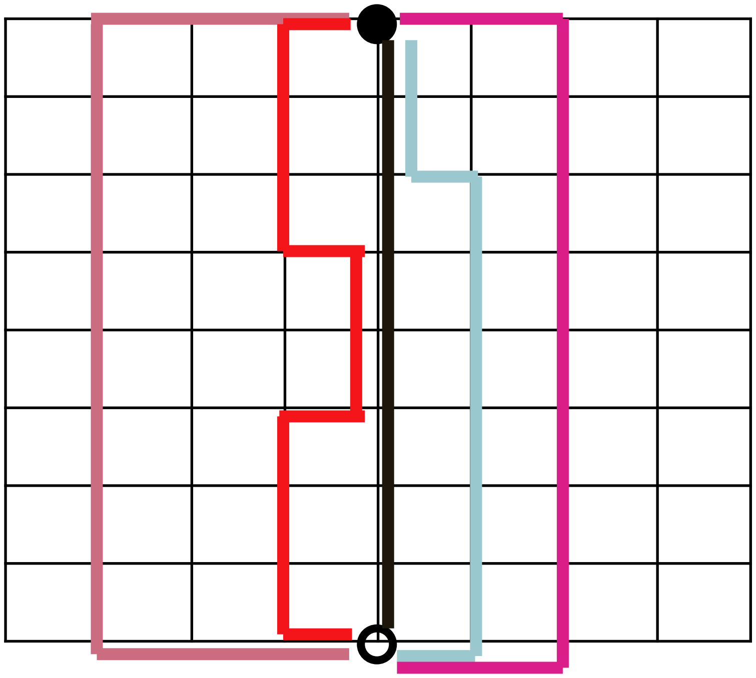
$$P(a) \approx \frac{4}{8} = \frac{1}{2}$$

The length–weighted average

$$\sum_{a \in \Gamma_i} \frac{l_a}{L_i} \frac{N_a}{N}$$

approximates the sampling probability of a path $P(\Gamma_i)$.

BootRouting approximates sampling probabilities in stochastic path generation by repeatedly sampling overlapping routes

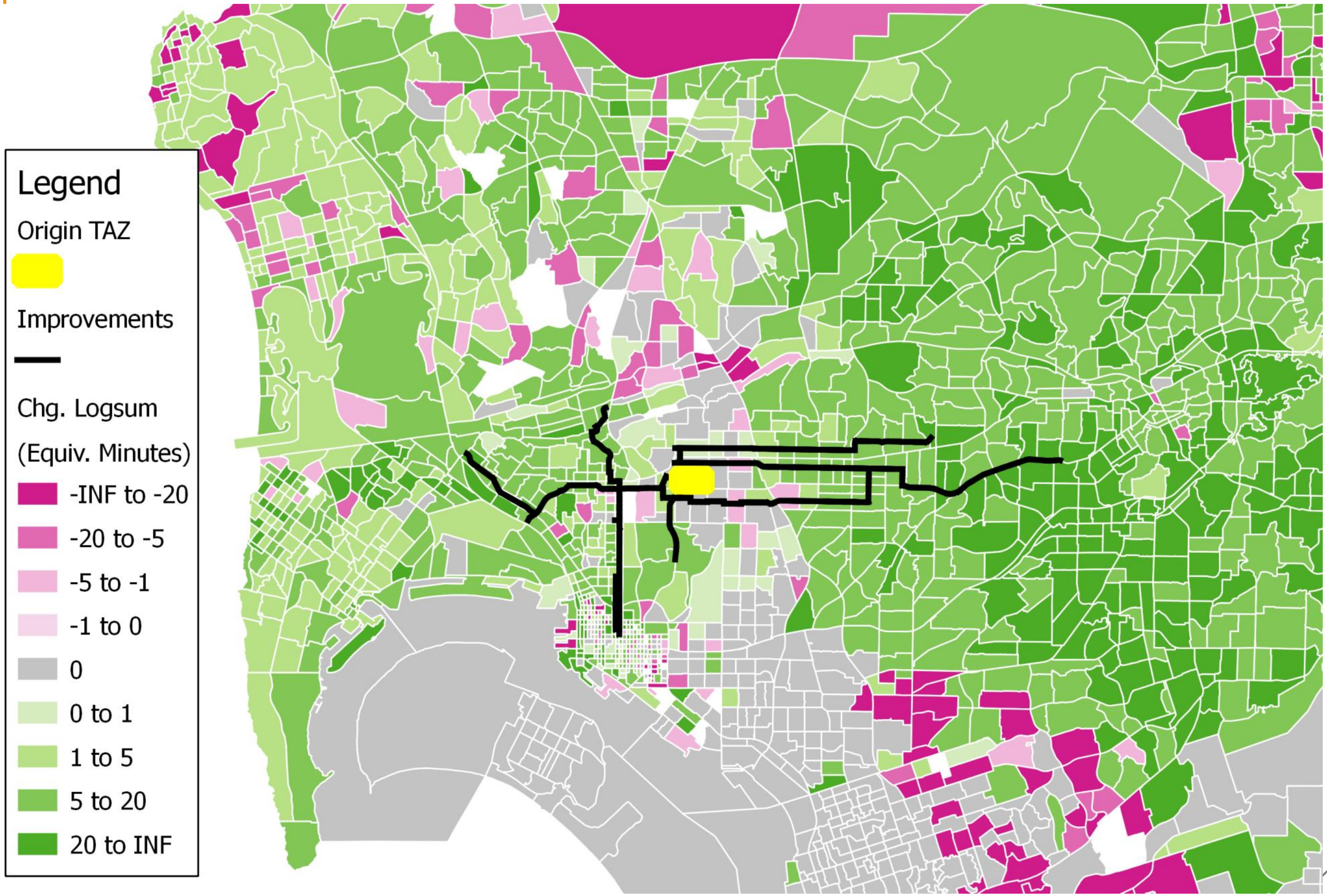


Resampling routes gives

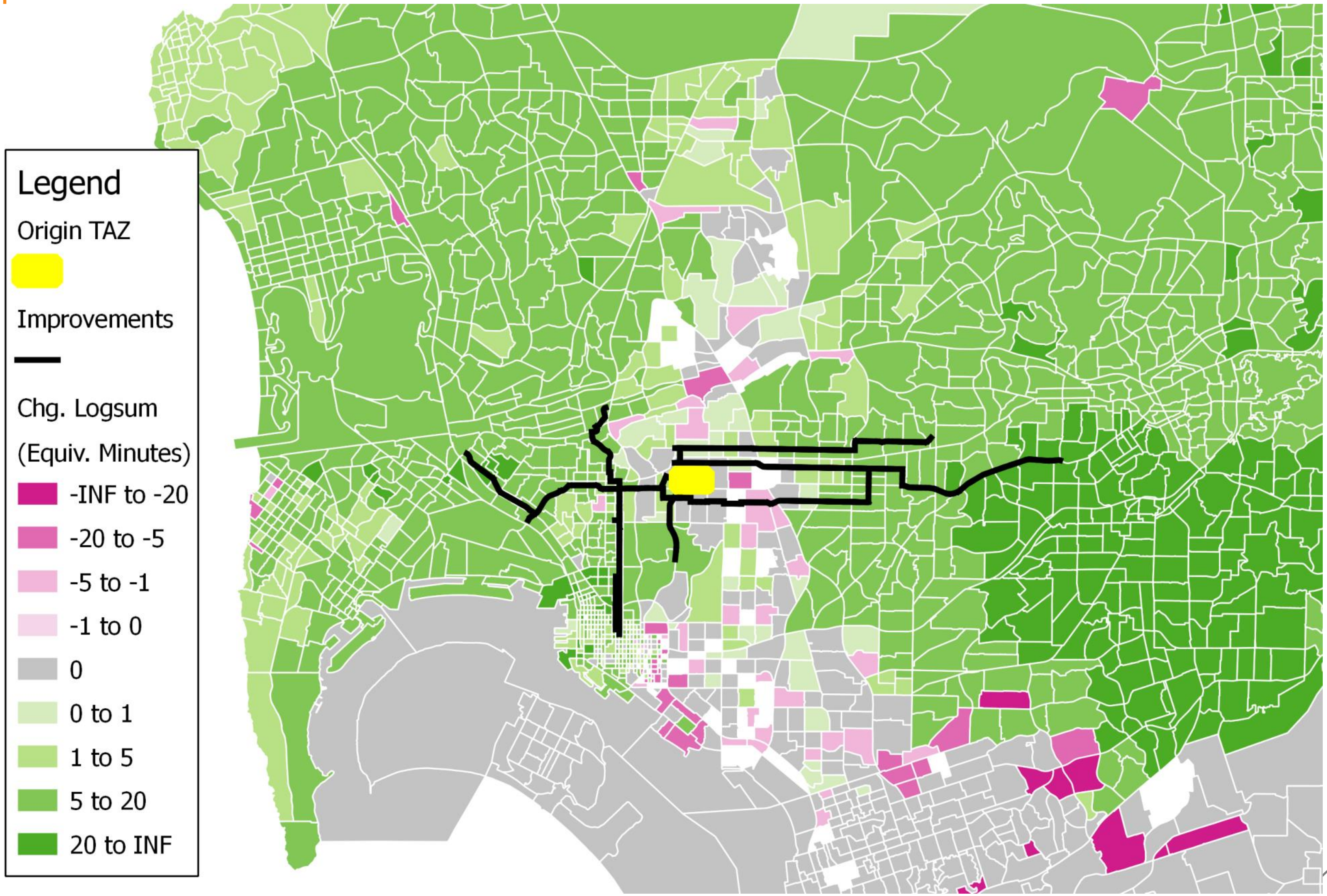
- fixed choice set size
- corrected probabilities
- consistent logsum

Sensitivity Test Results

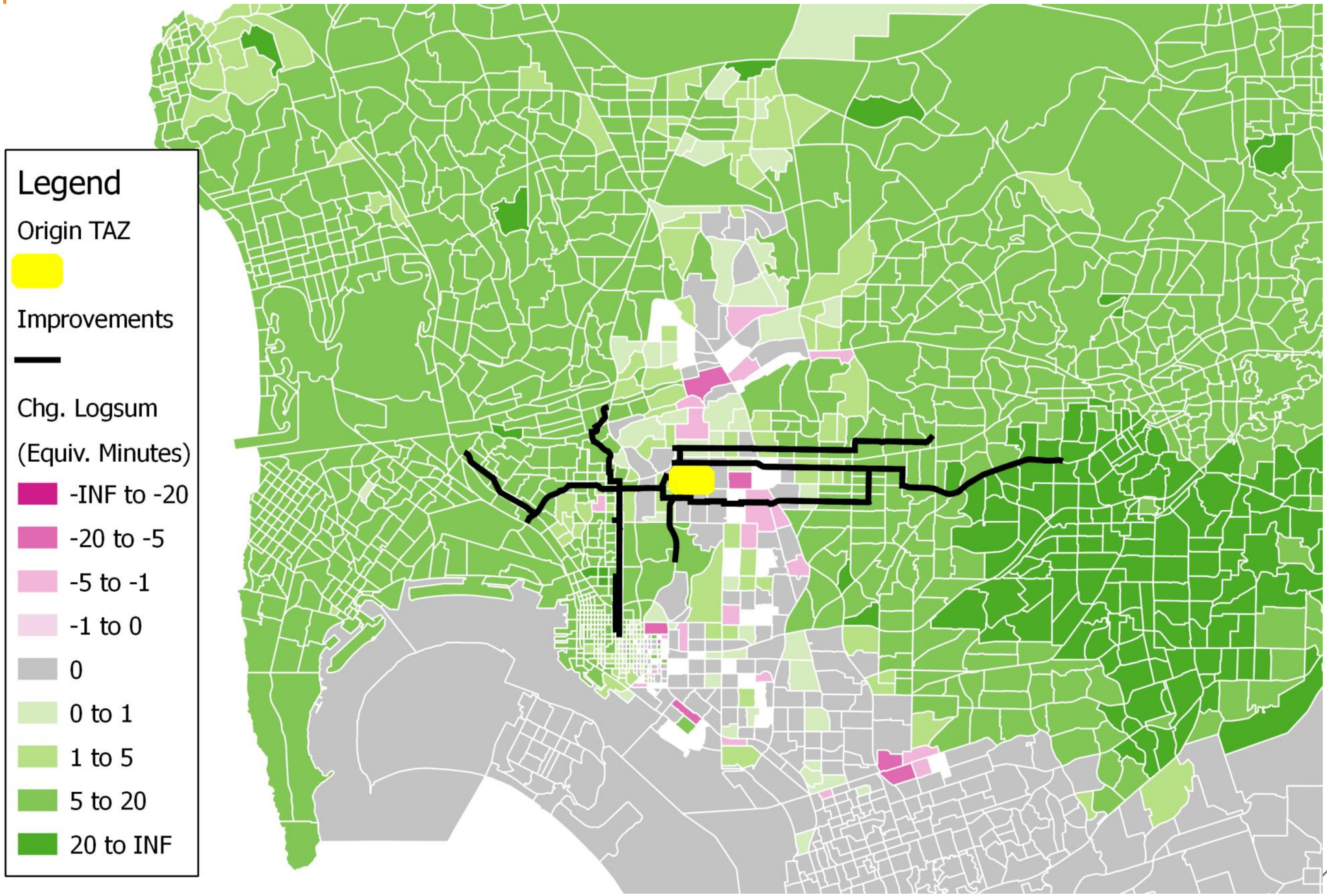
Change in logsum: min. N = 8, size = 2



Change in logsum: min. N = 16, size = 4



Change in logsum: min. N = 24, size = 6



Target choice set size stratified by distance, then normalized to one

Distance (mi.)	0.0 to 0.5	0.5 to 1.0	1.0 to 2.0	2.0 to 10.0	10.0 to 20.0
Total choice set size	1.0	1.5	2.0	6.0	1.0
Min. sample count	not random	20	20	20	not random
Max. sample count	not random	100	100	100	not random

- Insufficient size at max. count for < 15% OD pairs
- 5k TAZs out to 20 miles
- 23k MGRAs out to 2 miles
- All–streets network
- Java, 12 processors

Run time 5 hours, linear in zones.

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