Rolling the Dice with ABM - A systematic study of microsimulation variability

Gaurav Vyas, Mehedi Hasnat (Bentley Systems)

Rajib Sikder, Peter Xin (City of Edmonton)

Edmonton Person Travel Model

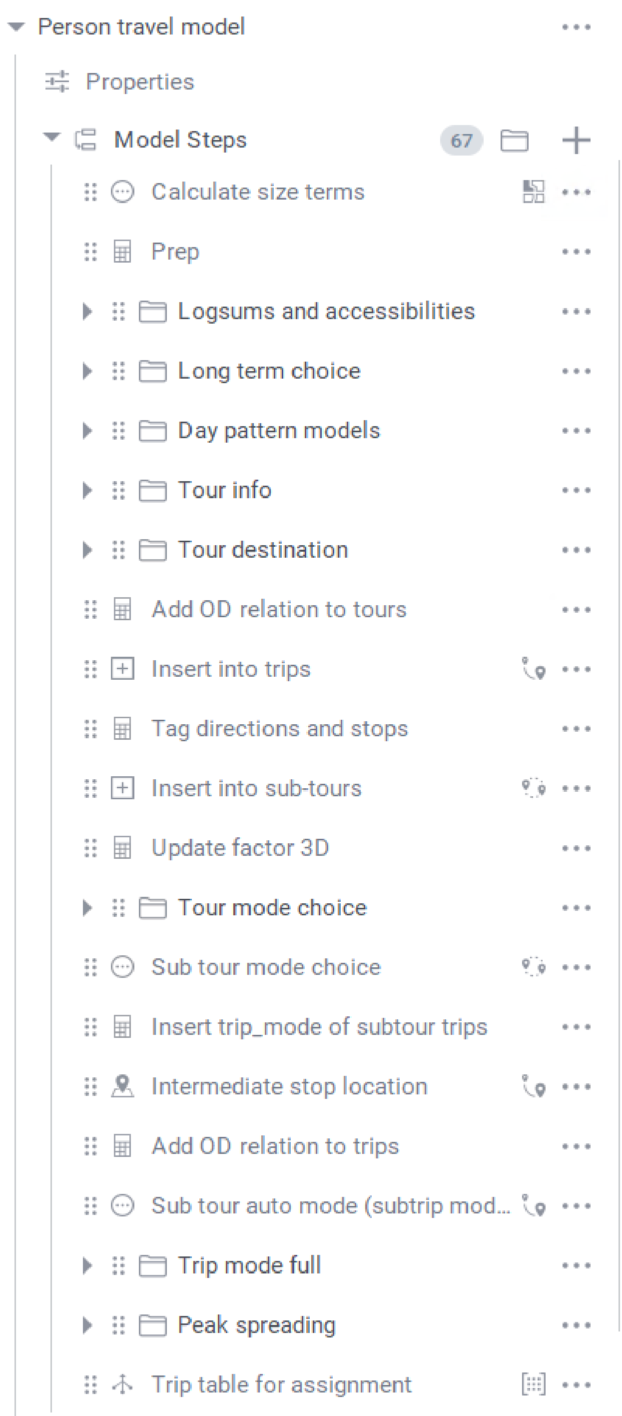
Disaggregate tour-based travel demand model

Key features:

- Explicit work from home
- Data-driven tour-pattern model
- Detailed segmentation for accessibility impacts
- Enhanced walk and bike modes
- Peak spreading

Software:

- Re-platformed from custom python code to OpenPaths AGENT demand modelling platform



Randomness inherent in disaggregate models

Conventional discrete choice model produces fractional probabilities

Microsimulation requires discretizing of fractional probabilities

Conversion of fractional probabilities can be done in many ways, Monte-Carlo being the most common

How to chose the method? What are the desired properties?

Desired properties of discretizing

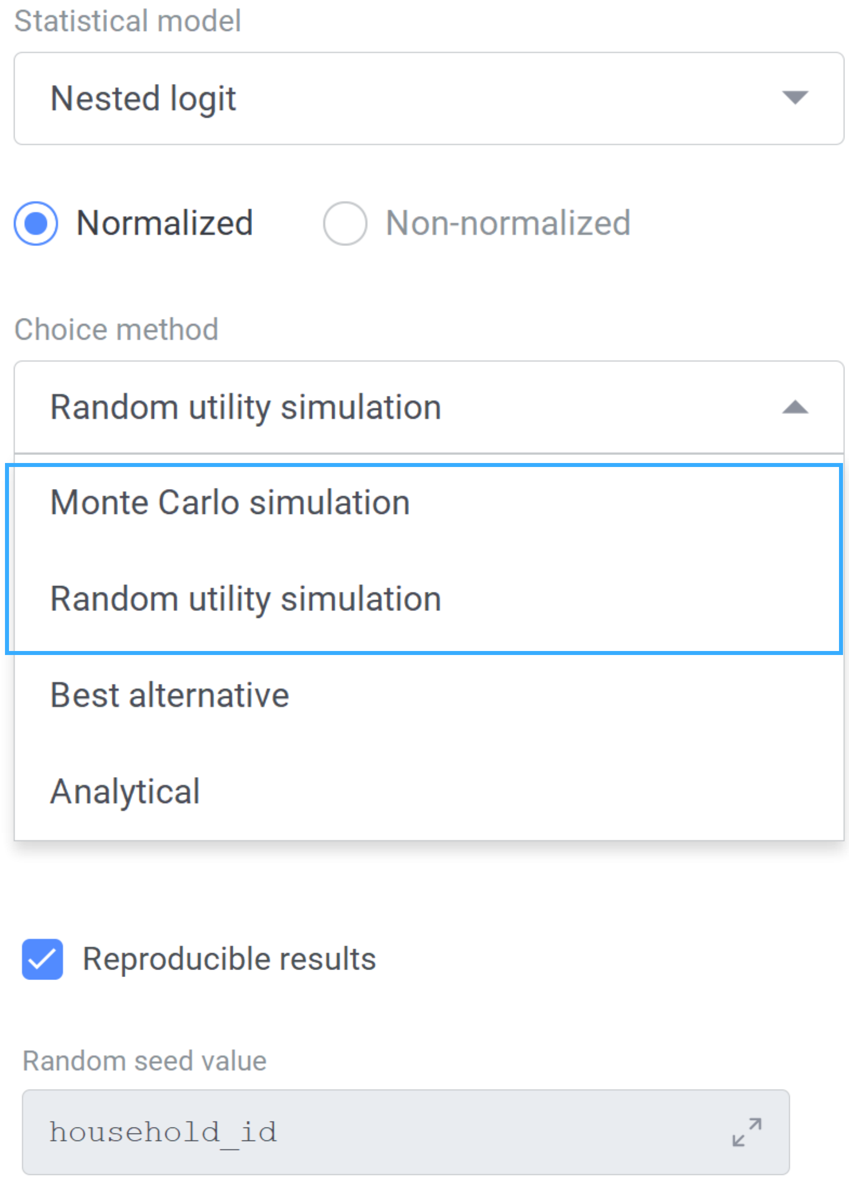
		Aggregate	Disaggregate
Unbiasedness		Aggregate shares approximate probabilities	N/A
Repeatability	*With same inputs*	Replication of shares	Replication of individual choices
Logical elasticity	*When inputs change*	Shares change in the same direction as probabilities	Logical switches at individual level
Continuity	*Small change in inputs produces weak response*	Small variations in shares	Small change in individual switches i.e. almost diagonal switching matrix

Edmonton Bentley

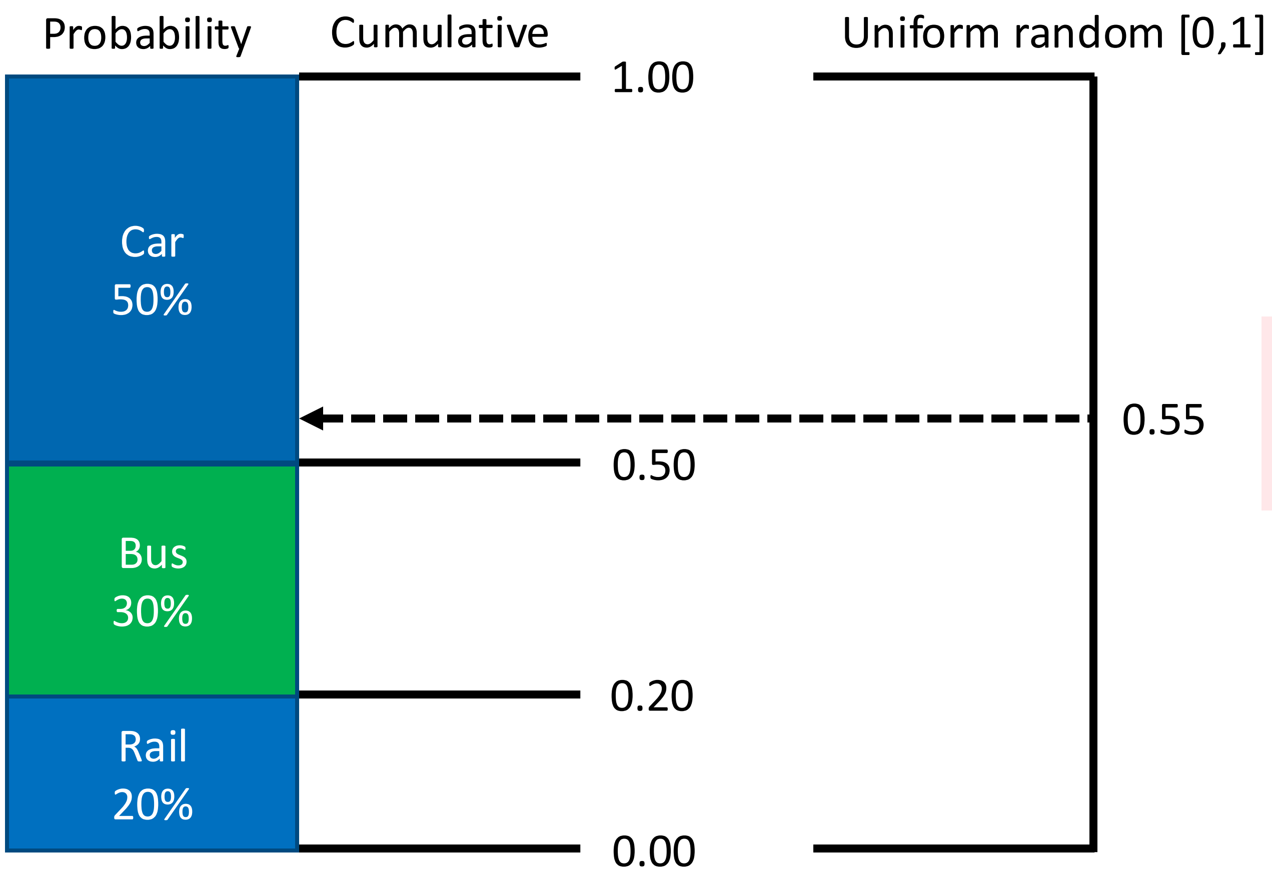
Choice methods

Monte-Carlo with a fixed random seed for each individual choice

Random utility simulation with controlled random number

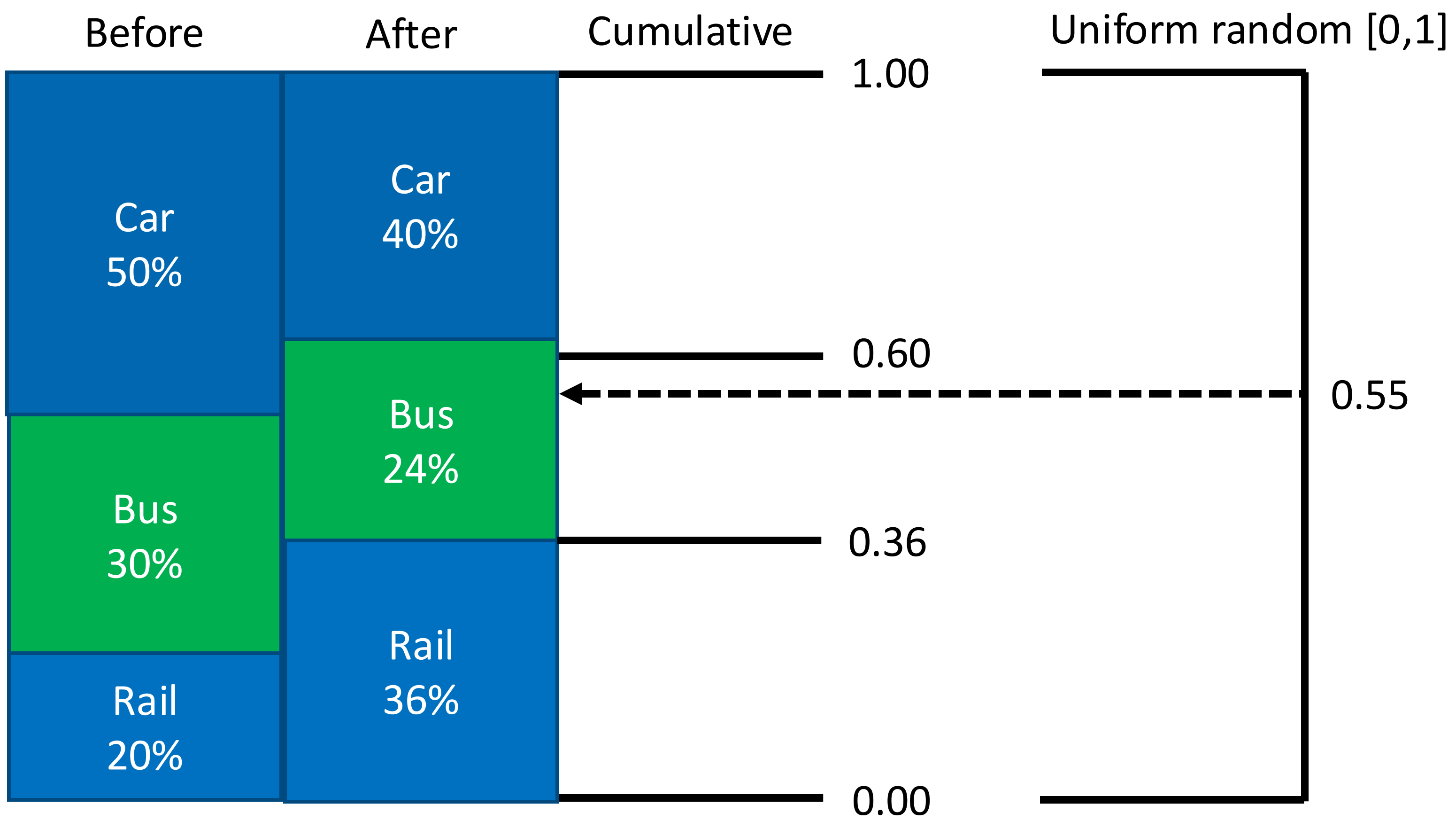


Monte-Carlo base choice



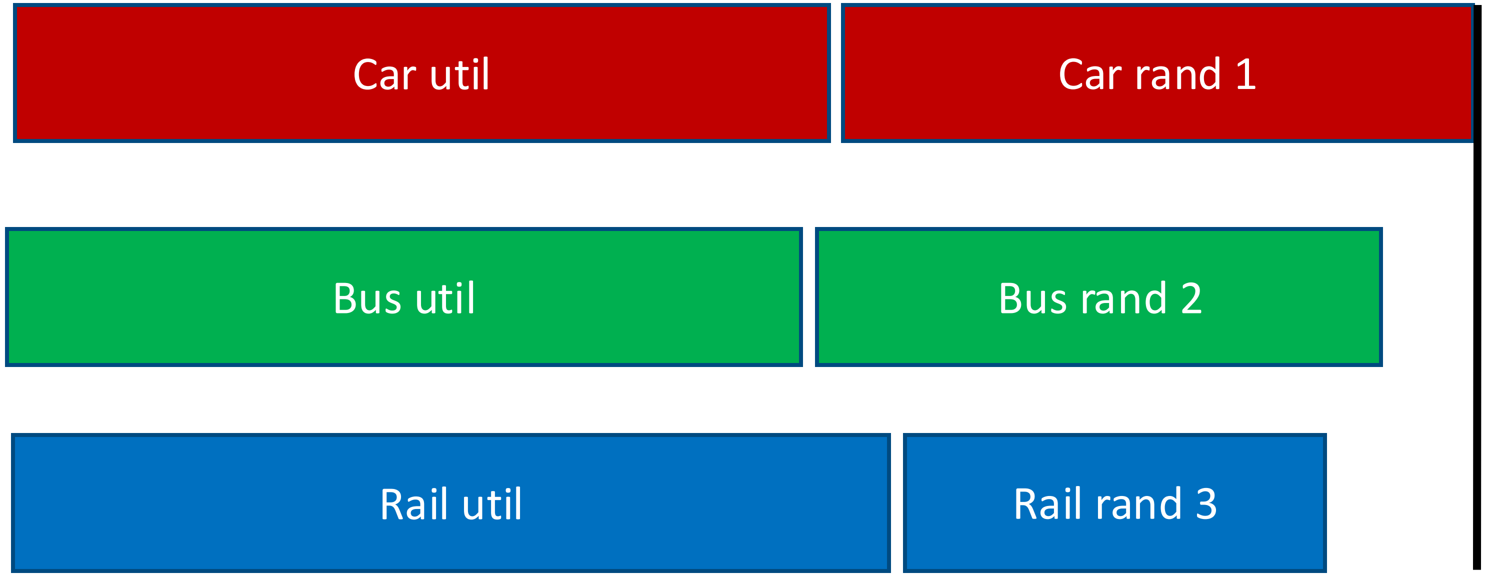
If probabilities and random number are preserved, the choice of car is repeated

Monte-Carlo after rail improvement



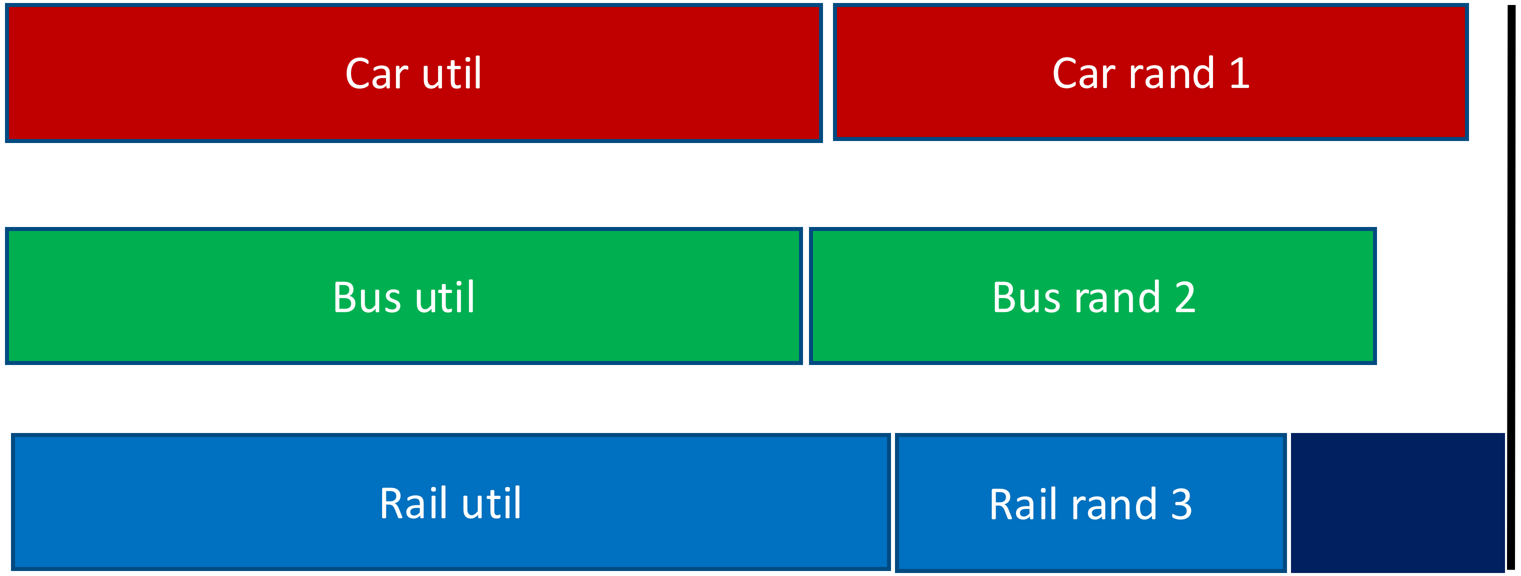
Illogical switch from car to bus due to rail improvement despite preservation of random number

Random utility simulation – base choice



Car chosen by the greatest total utility

Random utility simulation – after rail improvement



Rail chosen by the greatest total utility

If random utility terms are preserved, switch can only happen to the improved alternative; no need to calculate probabilities

Model runtimes

1.2 million people

1,700 TAZs

Runtime for 1 iteration of demand model for a 100% population:

- Monte-Carlo: 25 minutes
- Random Utility: 24 minutes

Machine: Intel® 2.8GHz, 20 cores, 32 GB RAM

Experimental design (1)

Improvement in the bike condition in downtown Edmonton

6 hypothetical bike conditions scenarios

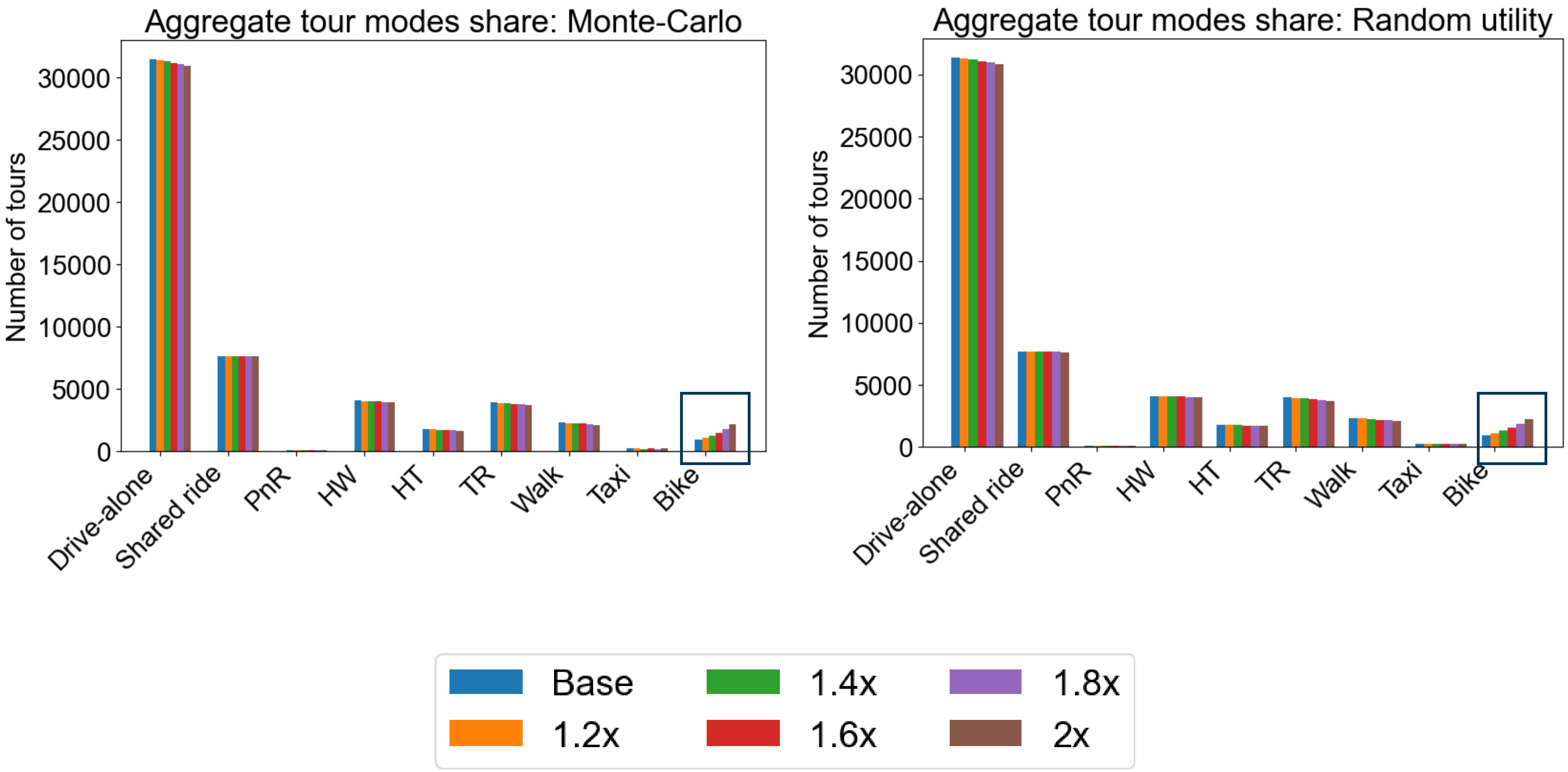
- Base
- Improvement of 1.2x
- Improvement of 1.4x
- Improvement of 1.6x
- Improvement of 1.8x
- Improvement of 2x

Two choice methods

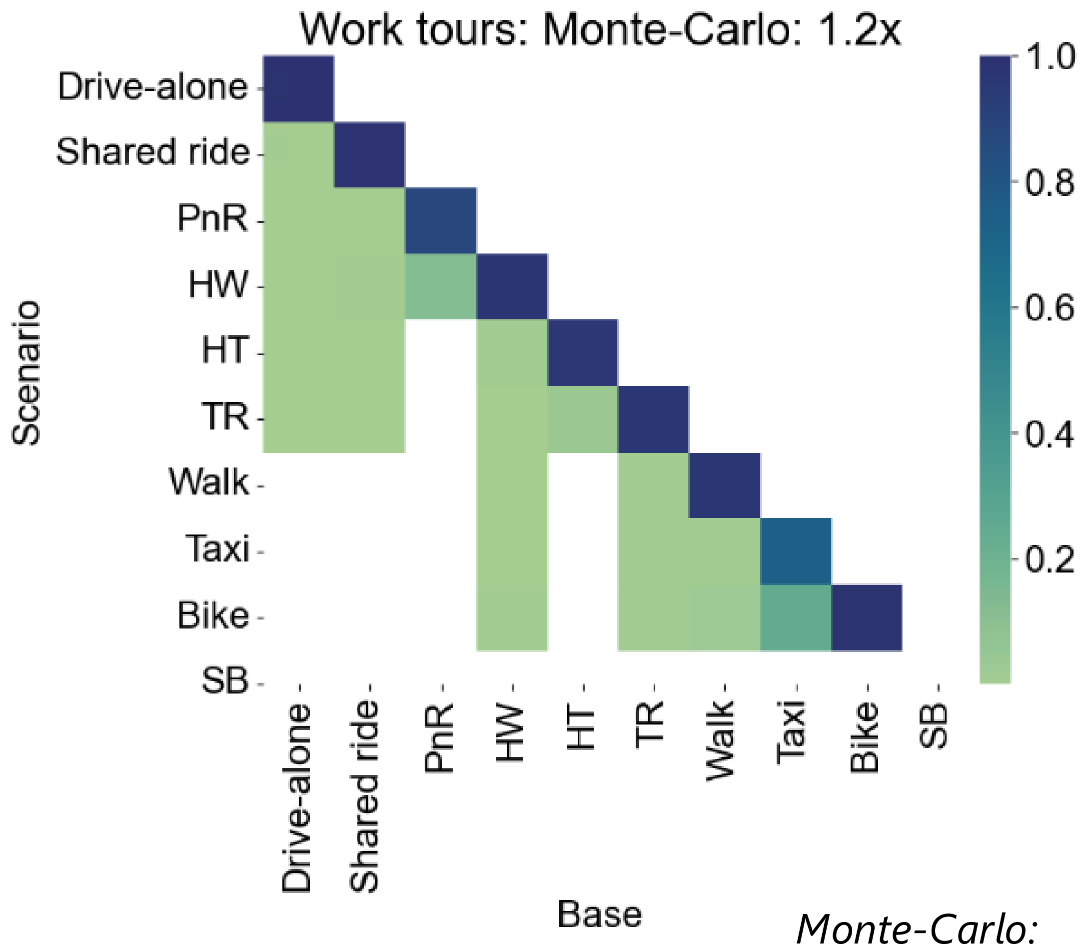
- Monte-Carlo with fixed random seed
- Random utility with fixed random seed

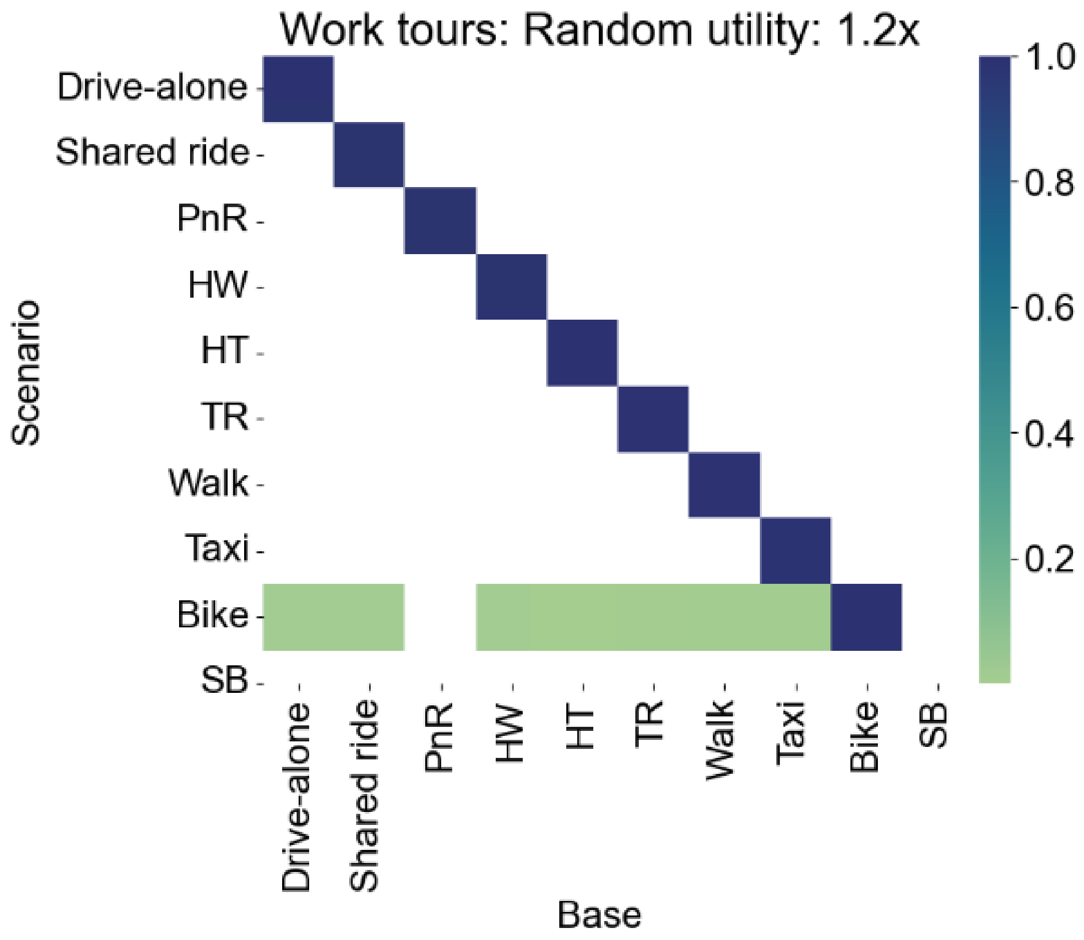
Impact on the tour mode choice is analyzed: Controlled test, no change in tour characteristics prior to mode choice

Result analysis: Logical elasticity, aggregate level



Result analysis: Logical elasticity, disaggregate level, 1.2x improvement





Monte-Carlo:

- *Illogical switches to nearby alternatives*
- *No switch to Bike from auto modes*

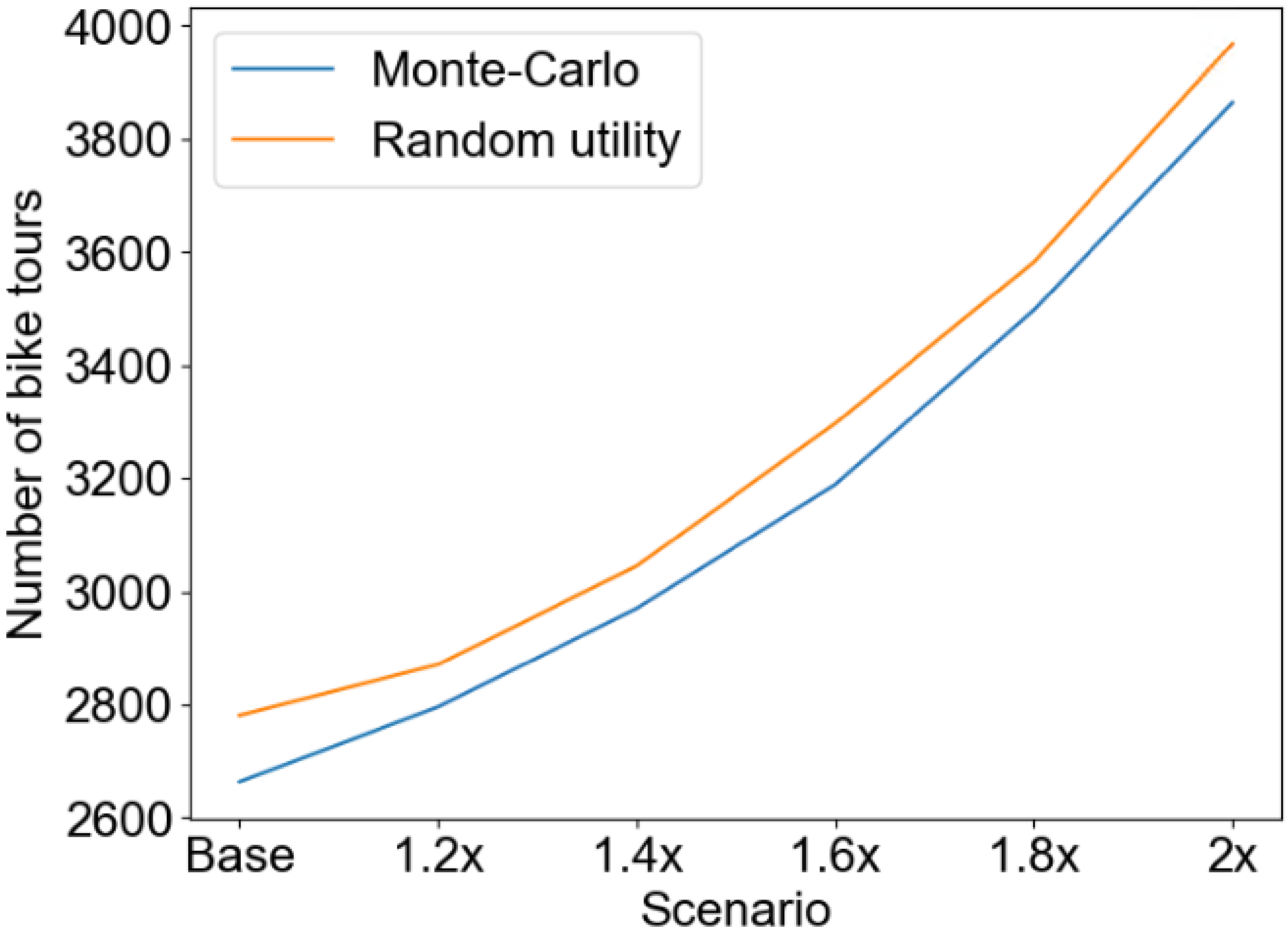
Random utility:

- *Switching to Bike only*
- *No switch to Bike from PnR*

Edmonton Bentley

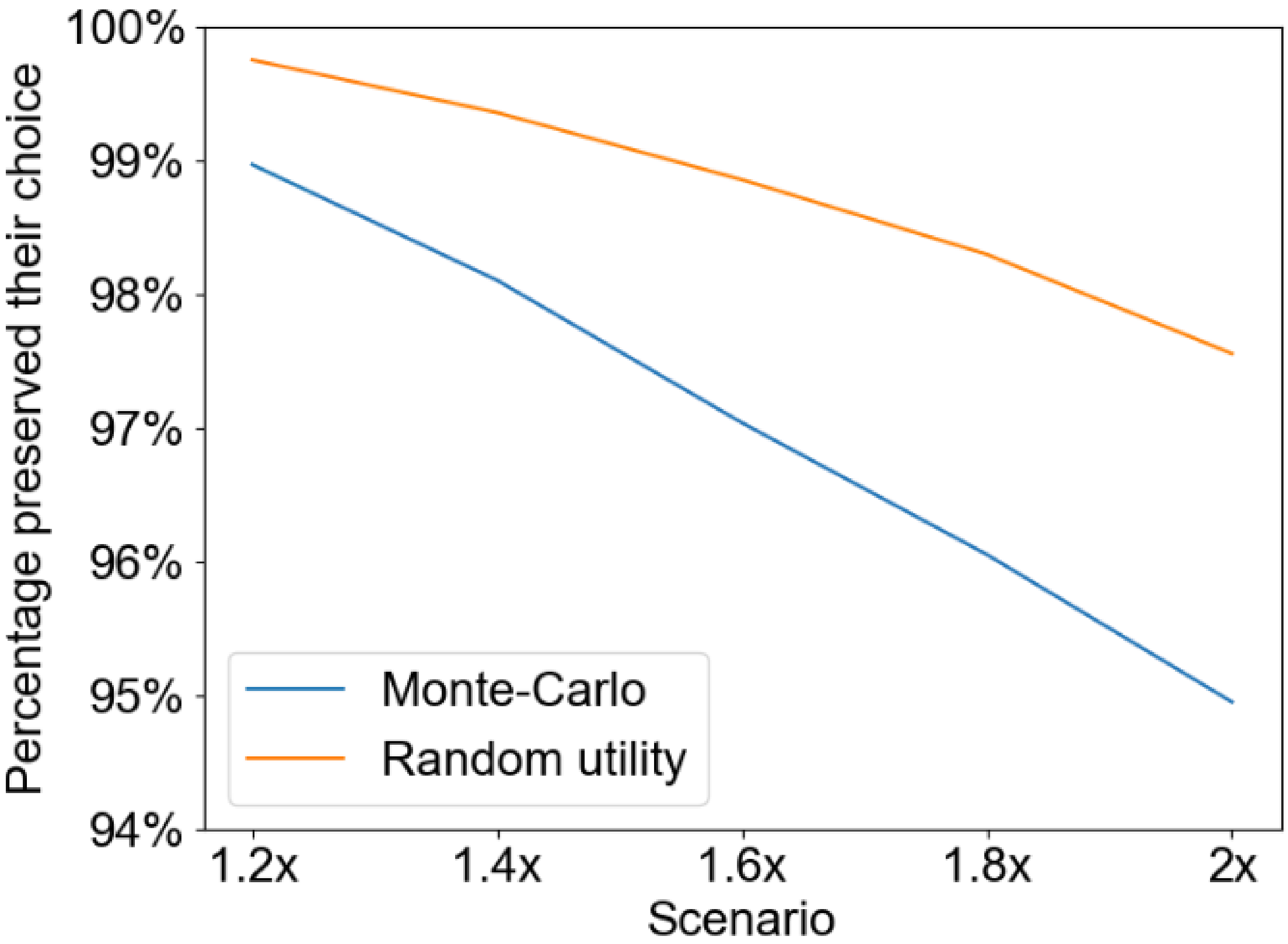
Result analysis: Continuity, aggregate level

At the aggregate level, both methods showed a logical continuity



Result analysis: Continuity, disaggregate level

Monte-Carlo shows bigger impact of a smaller change, attributing to so-called Monte-Carlo variability



Conclusions (1)

		Monte-Carlo		Random utility	
		Aggregate	Disaggregate	Aggregate	Disaggregate
Unbiasedness		✓	N/A	✓	N/A
Repeatability	*With same inputs*	✓	✓	✓	✓
Logical elasticity	*When inputs change*	✓	✗	✓	✓
Continuity	*Small change in inputs produces weak response*	✓	✗	✓	✓

Edmonton Bentley

Experimental design (2)

Impact of change in input over a sequence of choice models

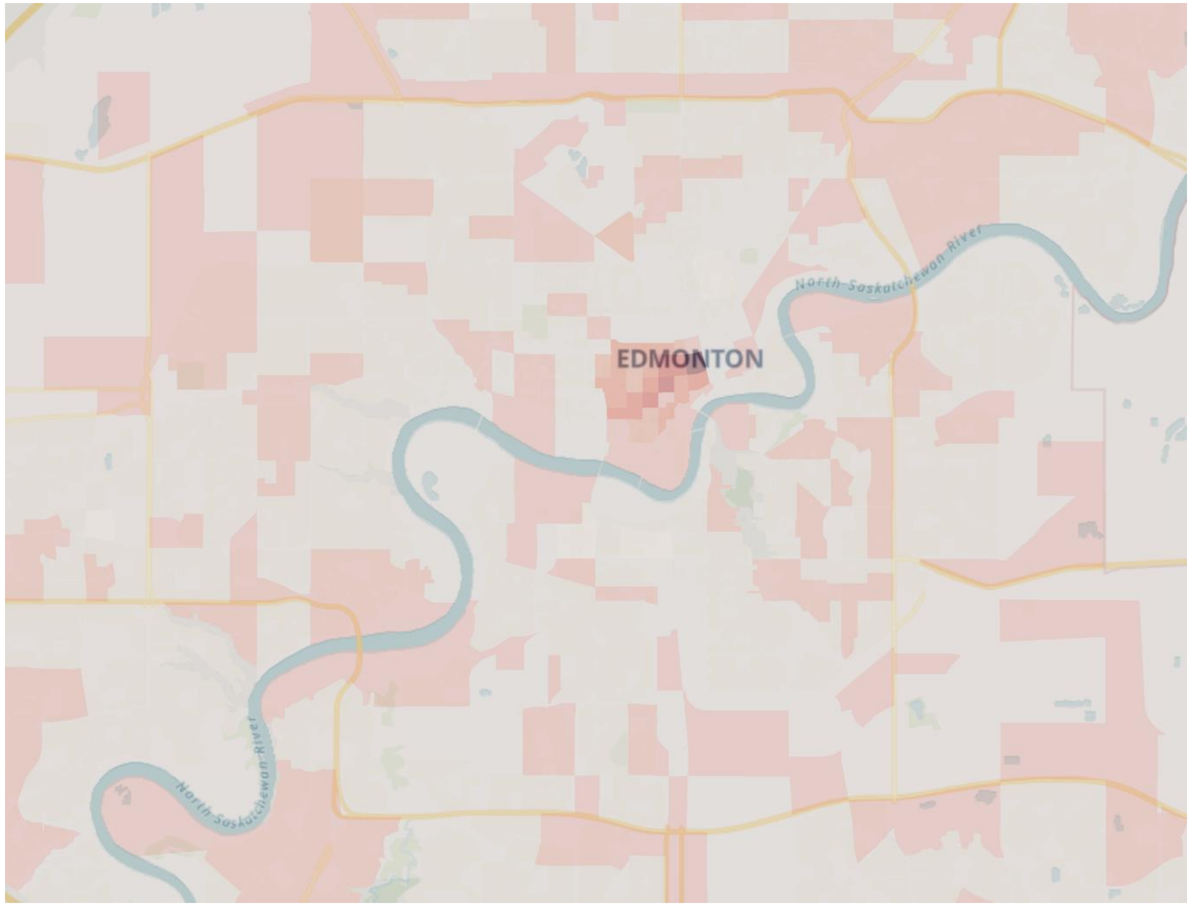
Increase in parking cost in downtown Edmonton

Two choice methods

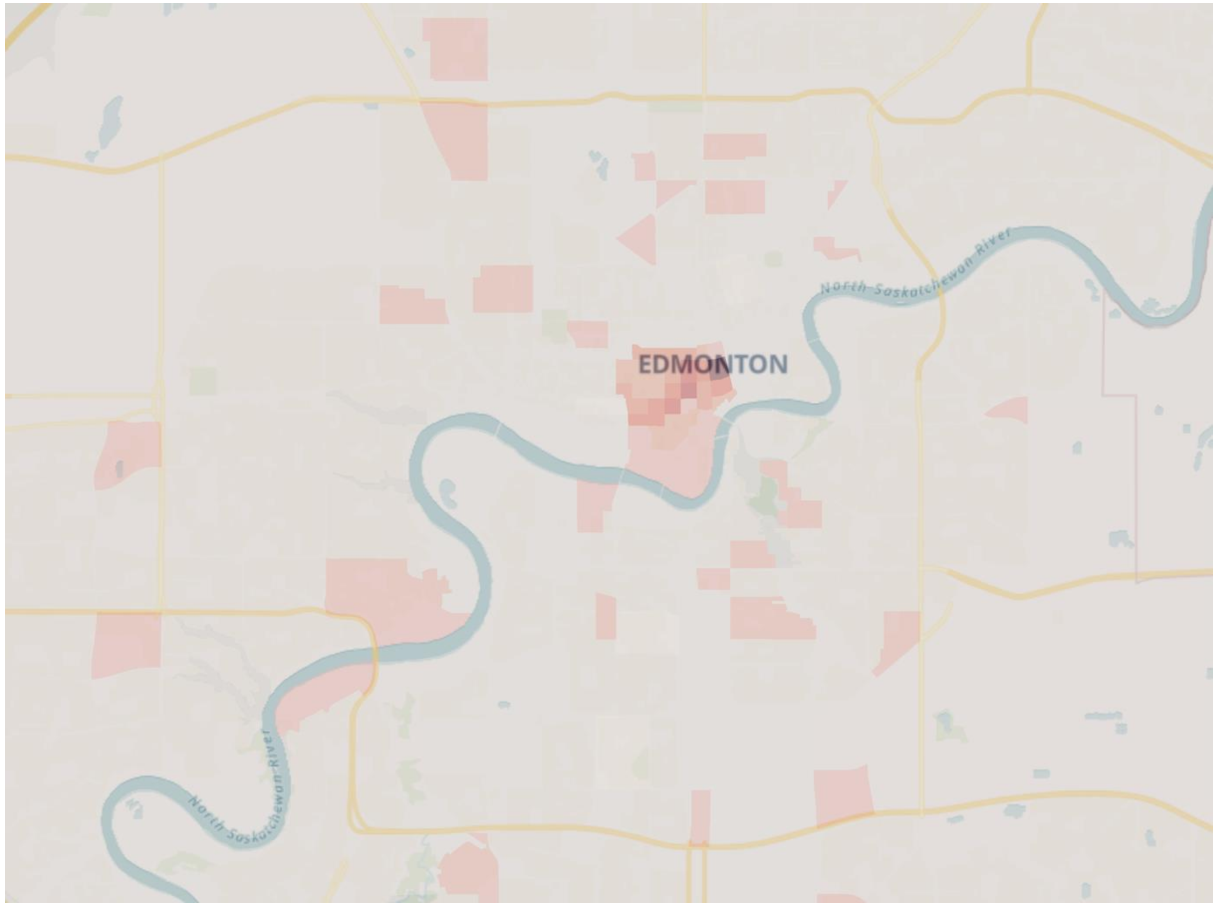
- Monte-Carlo with fixed random seed
- Random utility with fixed random seed

Impact on destinations

Monte-Carlo



Random Utility



Darker red → Reduction in number of trips destined in the zone

Person’s modality

Tour and activity patterns change due to a change in parking cost

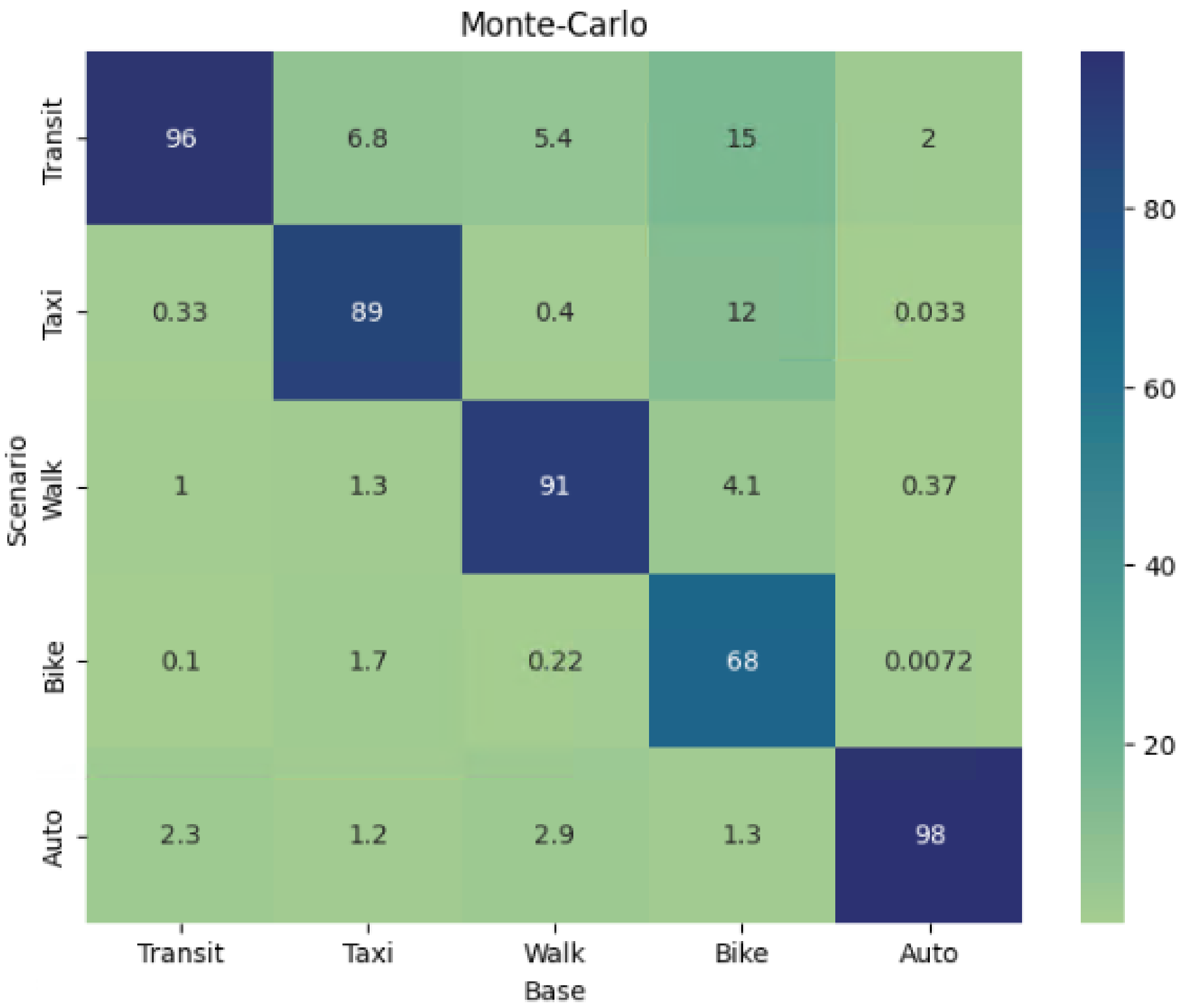
Analysis at individual tour/trip level is non-trivial

Individual analysis is possible at person level by classifying modality of each person

A person is categorized into one of five modality:

- Transit oriented: If any tour was by transit
- Taxi oriented: If not transit oriented and at least one tour by taxi
- Bike oriented: Neither transit nor taxi oriented and at least one tour by bike
- Walk oriented: Neither transit nor taxi not bike oriented, and at least one tour by walk
- Auto oriented: All tours are by auto mode

Comparison of individual modality: All persons



Conclusions (2)

Monte-Carlo’s failure to meet continuity test creates stochastic variation affecting the convergence of travel models

Monte-Carlo cannot ensure logical elasticity at disaggregate level:

- Switches shows adjacency bias

Random Utility is more stable than Monte-Carlo

Further research

Non-trivial to compare individual tours/trips when tours/trips are changed in the scenario

Further research is needed to allow comparing individual tours/trips between scenarios

Thank you!

Gaurav Vyas

Gaurav.vyas@bentley.com