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

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The challenge

Model probabilities

- Discrete choice models produce fractional probabilities

Discretization

- Microsimulation requires one discrete outcomes for each agent. Many methods exits

Individual choices

- Discretization method affects which alternative is chosen and how choices respond to changes in inputs

Two methods can produce similar aggregate results while behaving very differently at the individual level

Edmonton Bentley

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

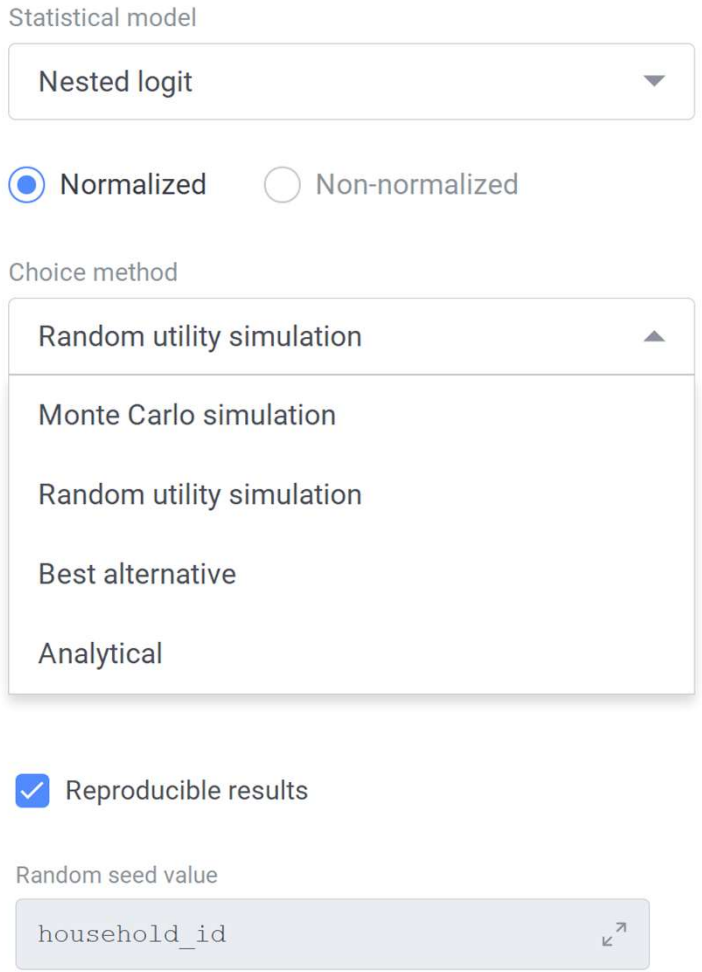
Edmonton Bentley

Choice methods

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

Random utility simulation with controlled random number

Analytical: No randomness



Analytical

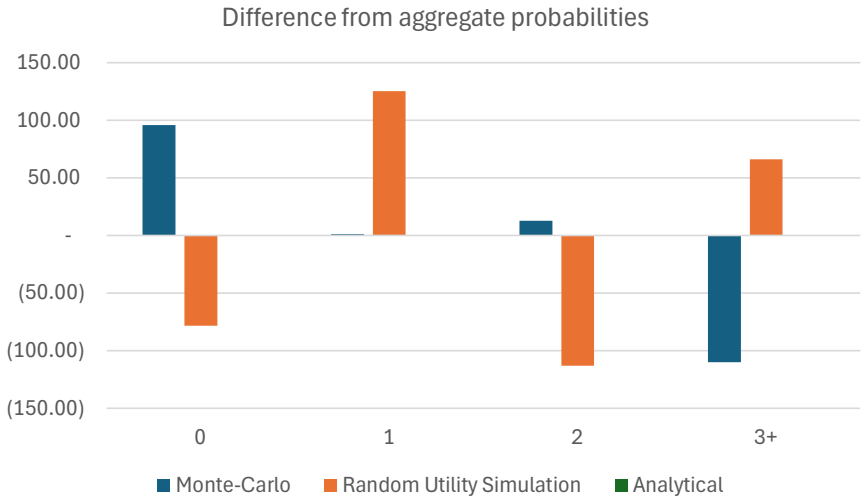
Optimization method for converting probabilities to discrete outcomes

P_{ins} = Probability of alternative *i* for agent *n* and segment *s*
Y_{ins} = Discrete outcome (1 or 0) for alternative *i* for agent *n* and segment *s*

Objective function: Minimize the deviation from model probabilities i.e. between P_{ins} and Y_{ins}
Constraints: Discrete outcomes should not violate aggregate probabilities

Comparison of three methods in replicating aggregate shares

Number of cars	Sum of probabilities	Discretized outcomes		
		Monte-Carlo	Random Utility Simulation	Analytical
0	1,607.8	1,512	1,686	1,608
1	24,014.2	24,013	23,889	24,014
2	14,863.8	14,851	14,977	14,864
3+	3,085.1	3,195	3,019	3,085



Analytical method replicates the aggregate shares

Experimental design

Model → Person travel model for Edmonton

Scenario → Improvement in the bike condition in downtown Edmonton

6 hypothetical bike conditions scenarios

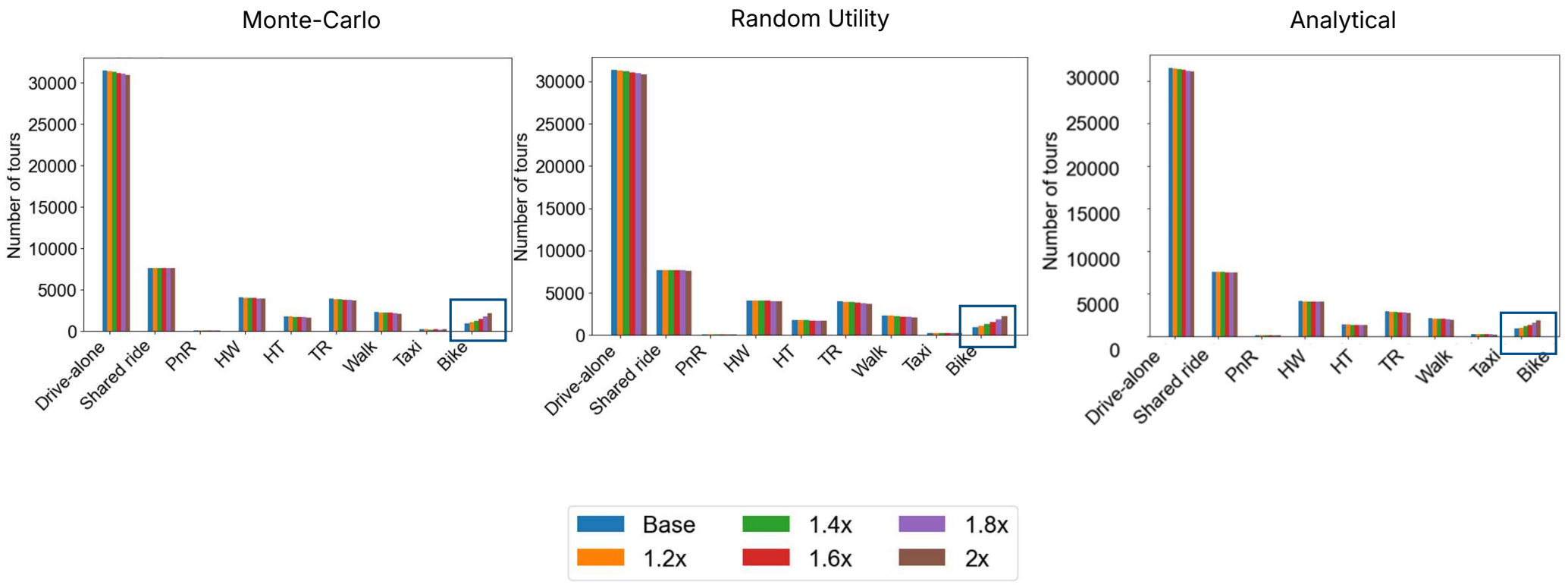
- Base
- Improvement of 1.2x
- Improvement of 1.4x
- Improvement of 1.6x
- Improvement of 1.8x
- Improvement of 2x

Three choice methods

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

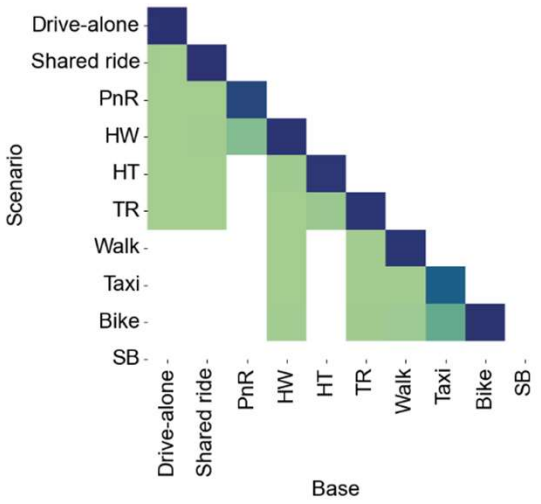
Impact on the tour mode choice is analyzed: Controlled test, no change in tour characteristics prior to mode choice

Result analysis: Logical elasticity, aggregate level

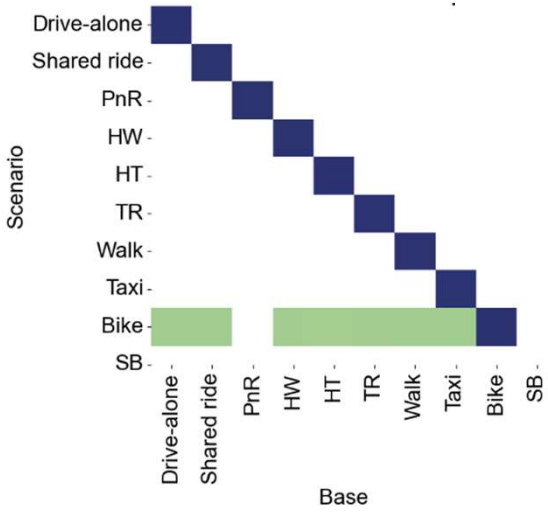


Result analysis: Logical elasticity, disaggregate level, 1.2x improvement

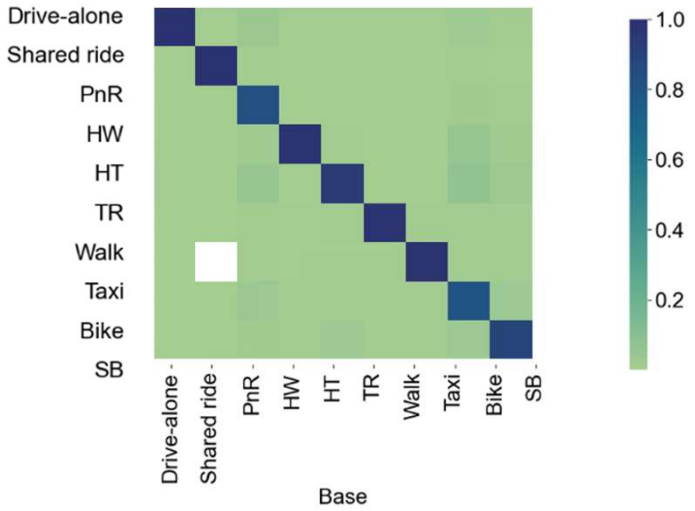
Monte-Carlo: 1.2x



Random Utility: 1.2x



Analytical: 1.2x



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*

Analytical:
- *Illogical switches in all direction*

Conclusions

	Aggregate	Disaggregate
Unbiasedness	Monte-Carlo = Random Utility < Analytical	
Repeatability	Monte-Carlo = Random Utility < Analytical	Monte-Carlo = Random Utility < Analytical
Logical elasticity	Monte-Carlo = Random Utility = Analytical	Analytical < Monte Carlo < Random Utility
Continuity	Analytical < Monte Carlo < Random Utility	Analytical < Monte Carlo < Random Utility

Experimental design (2)

Impact of change in input over a sequence of choice models

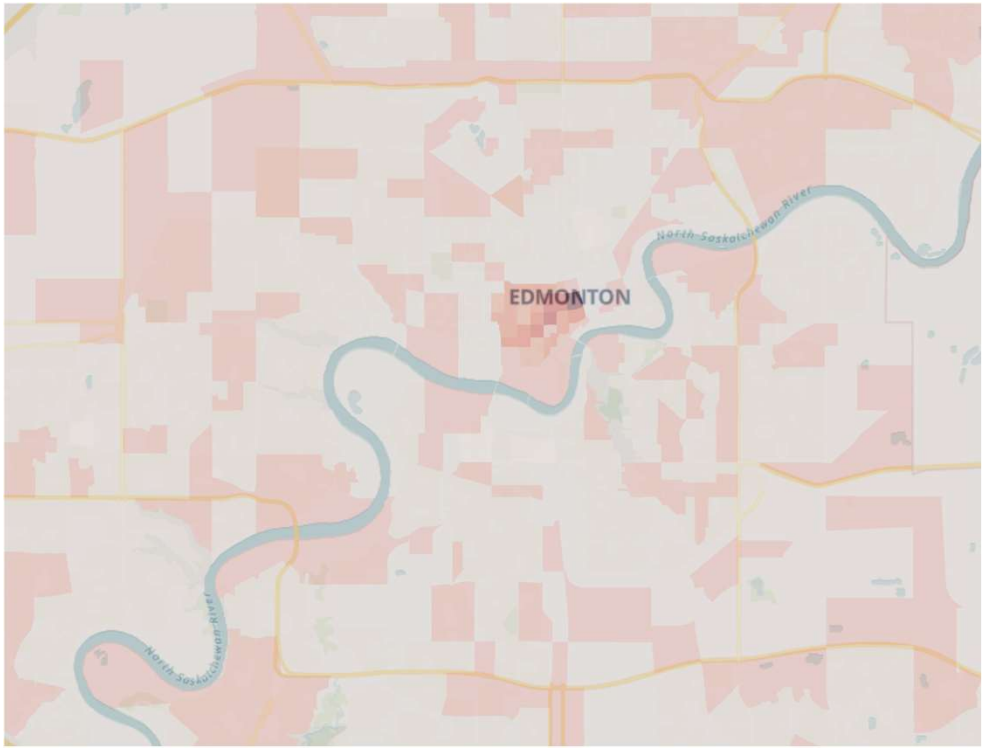
Increase in parking cost in downtown Edmonton

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

Conclusions (2)

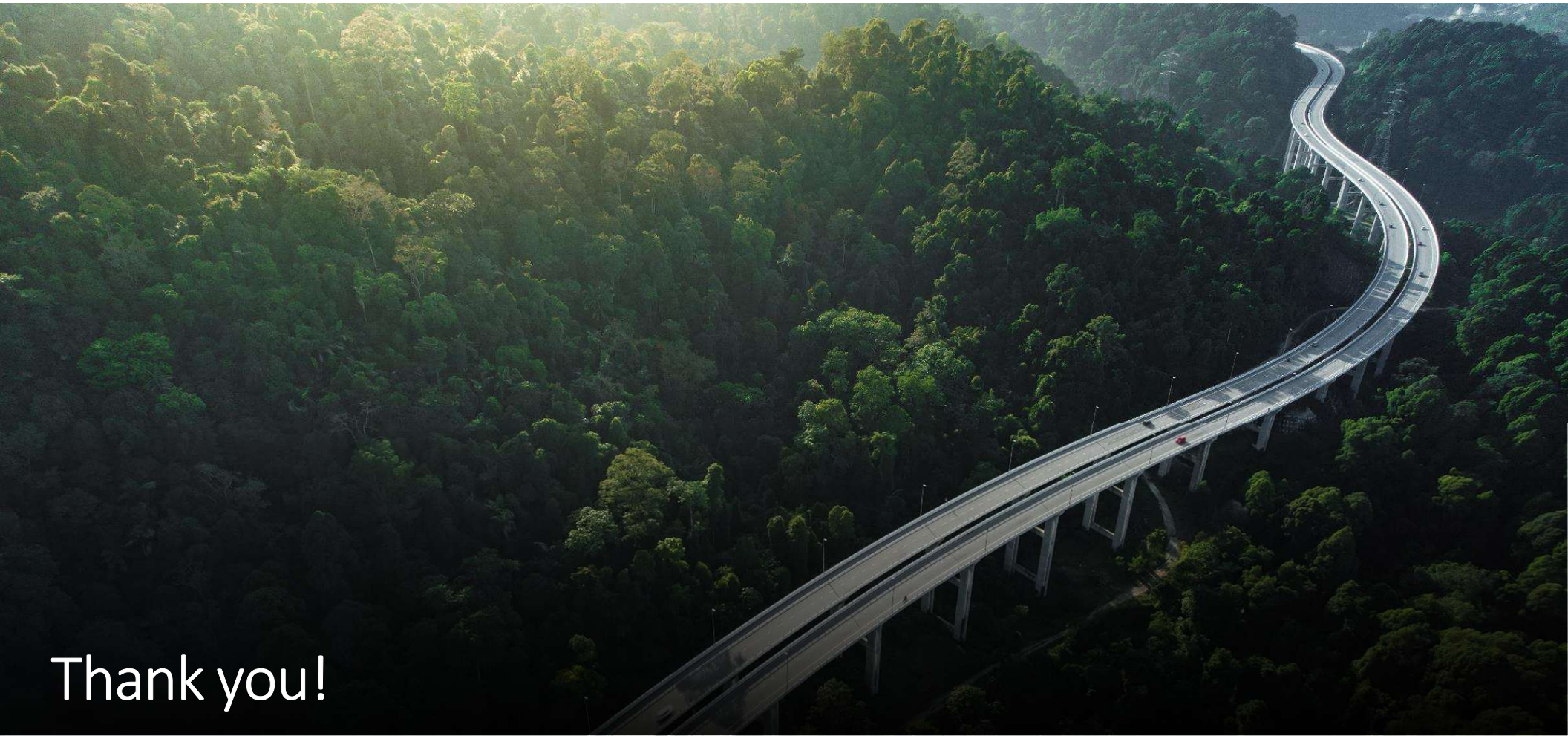
Monte-Carlo's failure to meet continuity test creates stochastic variation affecting the convergence of travel models

Analytical choice method is better suited to match the aggregate probabilities

Monte-Carlo and Analytical cannot ensure logical elasticity at disaggregate level:

- Monte-Carlo switches shows adjacency bias

Random Utility is more stable than Monte-Carlo



Thank you!

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