# Disaggregation of static OD-matrices for dynamic MATSim simulations

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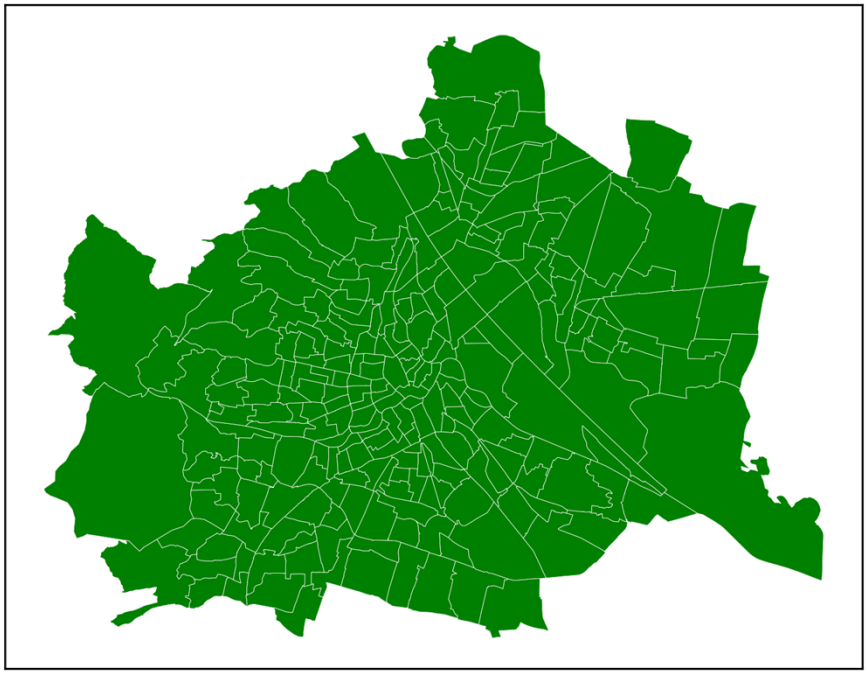
# Introduction and motivation

- What do we do?
  - Synthesizing coherent, distinguishable round trips from static OD matrices.
  - Considering five sociodemographic groups.
  - Reproducing data on the spatial distribution of home and work locations.
  - Adding correct temporal structure to the round trips by reproducing activity start times and durations.
- Why do we do it?
  - Activity-based demand models are well-suited for demand synthesis of downstream agent-based models.
  - However, they are data-intensive, especially up-to-date survey data is costly or sometimes unavailable.
  - We bridges demand data from widespread four-step models with agent-based simulation to enable a fully disaggregated analysis.

# Terminology and scenario

- Round trip
  - Round trip = home-based sequence of trips
  - Defined by a list of departure locations and the according departure times
- Vienna Scenario
  - Population of 10,000 car drivers (2%)
  - Spatial resolution: 250 zones
  - Temporal resolution: 24 hours

Vienna scenario: Traffic analysis zones



# Method

- Measurement model
  - Error function: $\mathrm{R}(x) = \sum_n |t_i - s_i(x)|$
    - $x$ … list of $n$ round trips
    - $t$ … target value
    - $s(x)$ … sample value
  - Likelihood of a sample: $b(x) \sim e^{-\mu \cdot R(x)}$
    - $R(x)$ … error function
    - $\mu$ … weighting of the error function
- Sampling from the probability distribution
  - Probability function: $\pi(x) = \frac{b(x)}{B}$
    - $b(x)$ … sampling weight of $x$
    - $B$ … normalizing constant … $B = \sum_x b(x)$

    → Metropolis-Hastings: $\pi(x) \sim b(x)$
  - Flötteröd (2025) provides a detailed specification of the approach

# Model specification

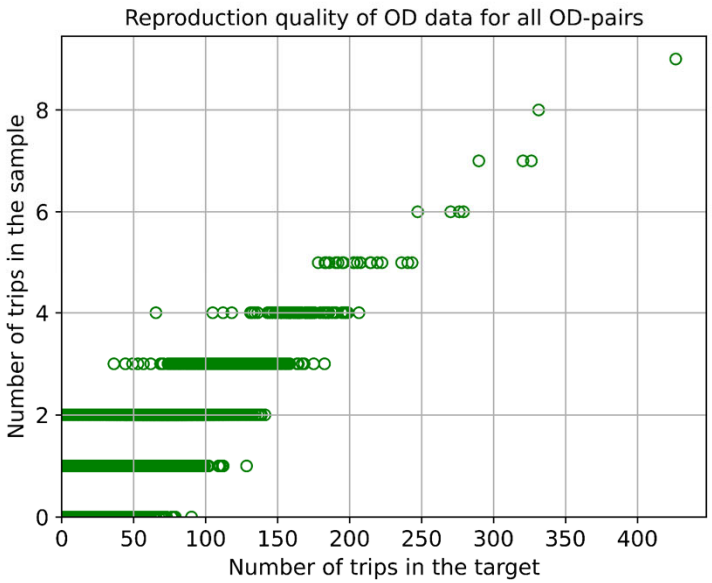
- Likelihood function:
  - $b(x) \sim e^{-E_{prior}(x)} \cdot e^{-[\mu_{OD} \cdot E_{OD}(x) + \mu_{Location} \cdot E_{Location}(x) + \mu_{Time} \cdot E_{Time}(x)]}$

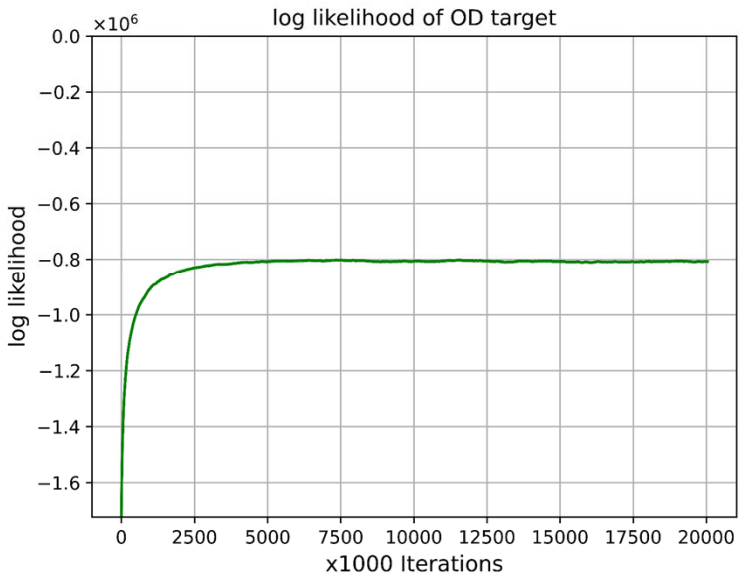
- Maximum entropy prior
  - The mean number of visited locations = 3.
  - Includes plausibility constraints
    - Round trips must be completed within 24 hours.
    - Arrival time must be before departure time.

- Reproduced data sets
  - Static 24h car OD matrices of all population groups with car access (PTV VISUM Modell Verkehrsverbund Ostregion).
  - Spatial distribution of home and work locations (PTV VISUM Modell Verkehrsverbund Ostregion).
  - Activity durations and end times of home and work activities (Österreich Unterwegs 2014).

# OD data reproduction quality

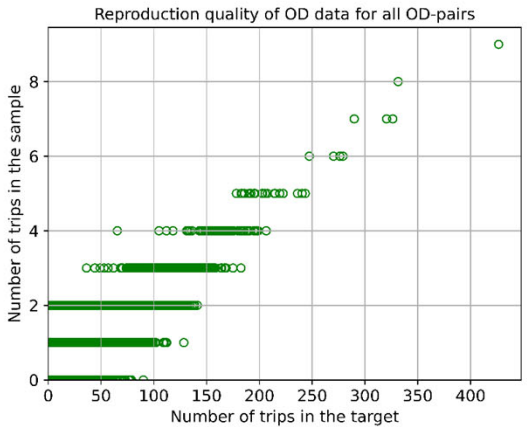
- Likelihood function:
  - $b(x) \sim e^{-\left[ E_{prior}(x) + \mu_{OD} \cdot E_{OD}(x) + \mu_{Location} \cdot E_{Location}(x) + \mu_{Time} \cdot E_{Time}(x) \right]}$

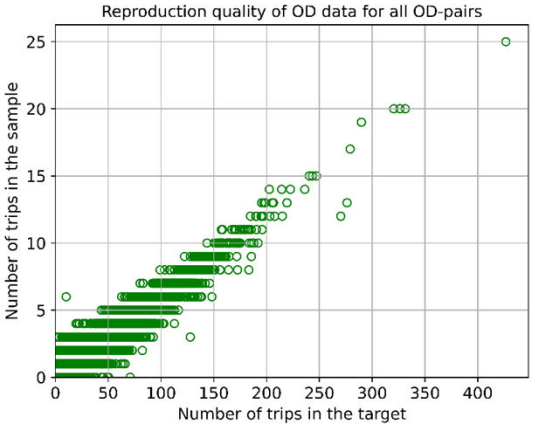


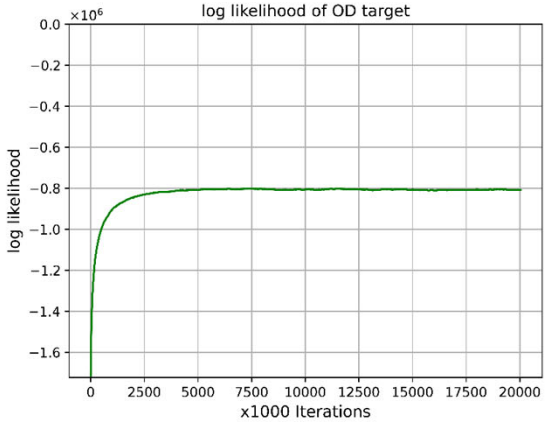



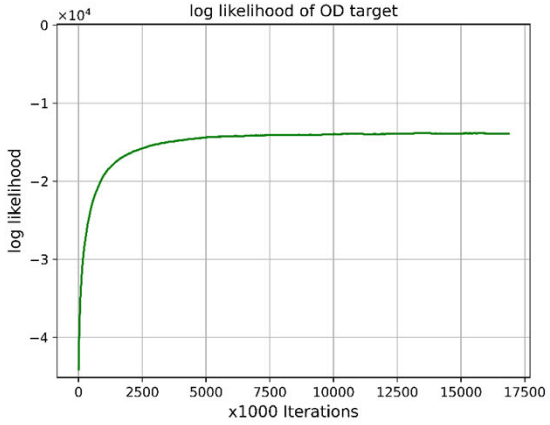
# Increased OD data reproduction quality due to a larger population

- 10% population (50k plans) versus 2% (10k plans).



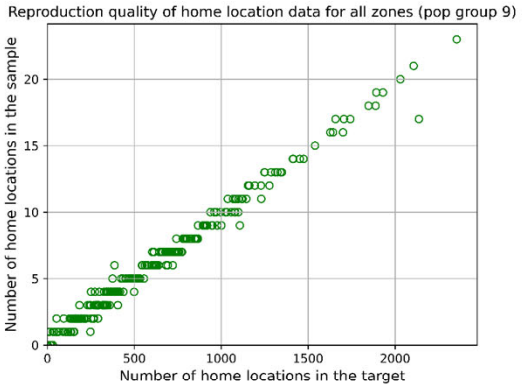



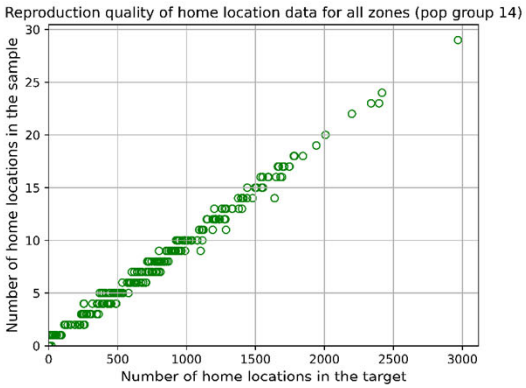



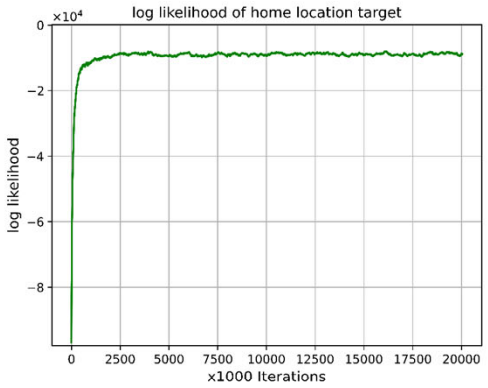



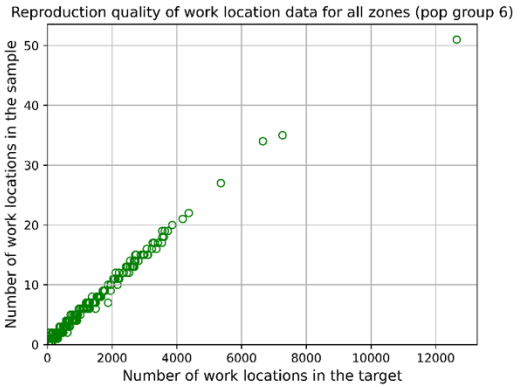
# Home and work location data reproduction quality

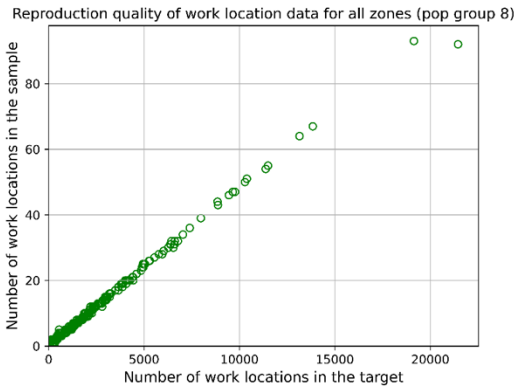
- Likelihood function:
  - $b(x) \sim e^{-[\ E_{prior}(x) + \mu_{OD} \cdot E_{OD}(x) + \mu_{Location} \cdot E_{Location}(x) + \mu_{Time} \cdot E_{Time}(x)\ ]}$

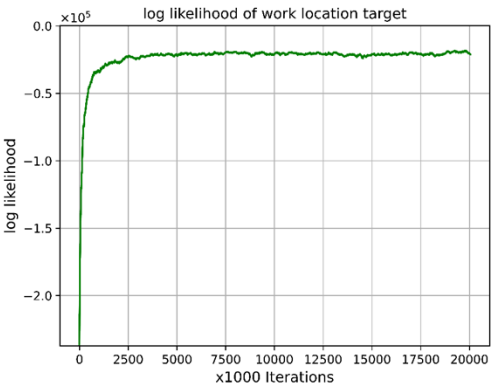


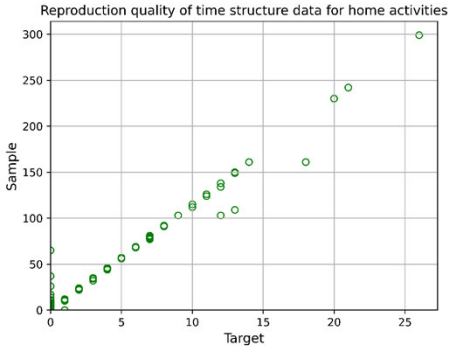



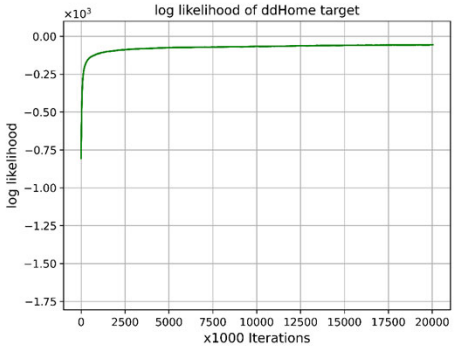



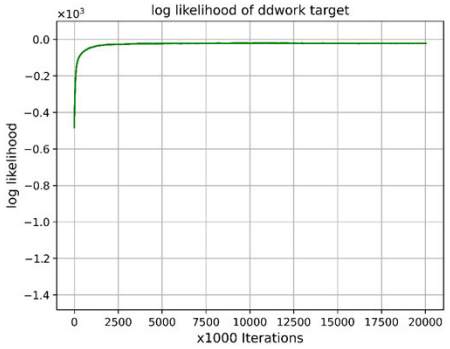
# Time structure reproduction quality

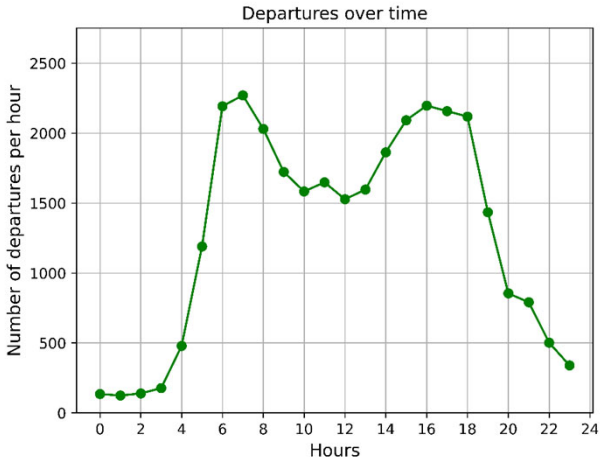
- Likelihood function:
  - $b(x) \sim e^{-[\ E_{prior}(x) + \mu_{OD} \cdot E_{OD}(x) + \mu_{Location} \cdot E_{Location}(x) + \mu_{Time} \cdot E_{Time}(x)\ ]}$



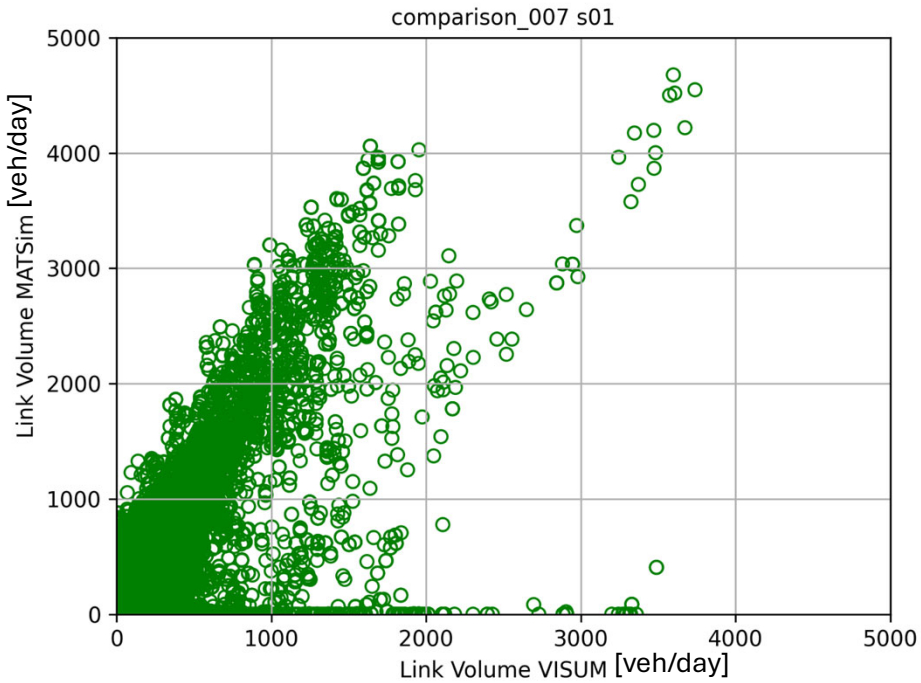


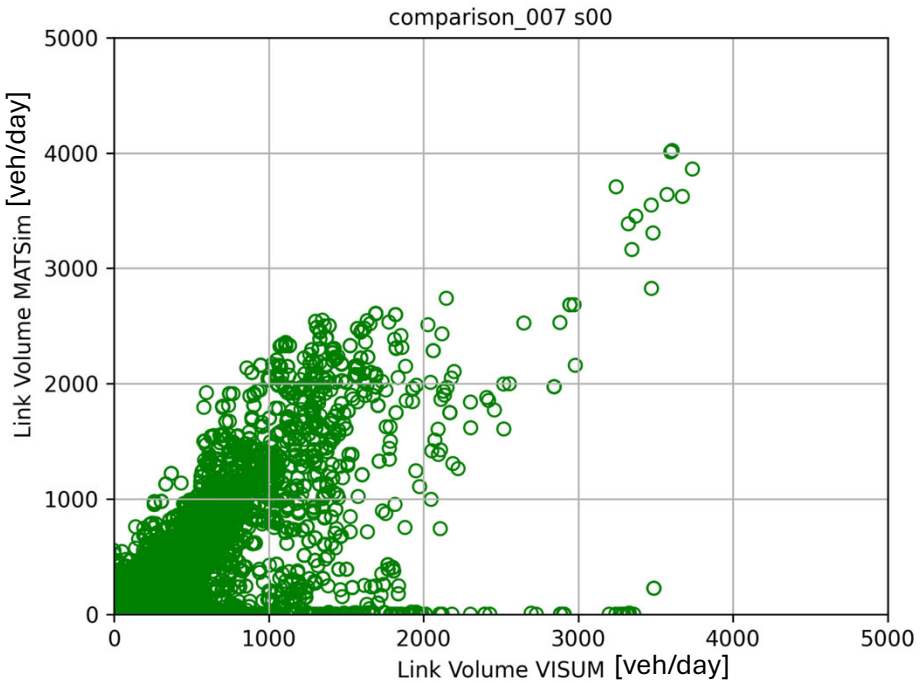


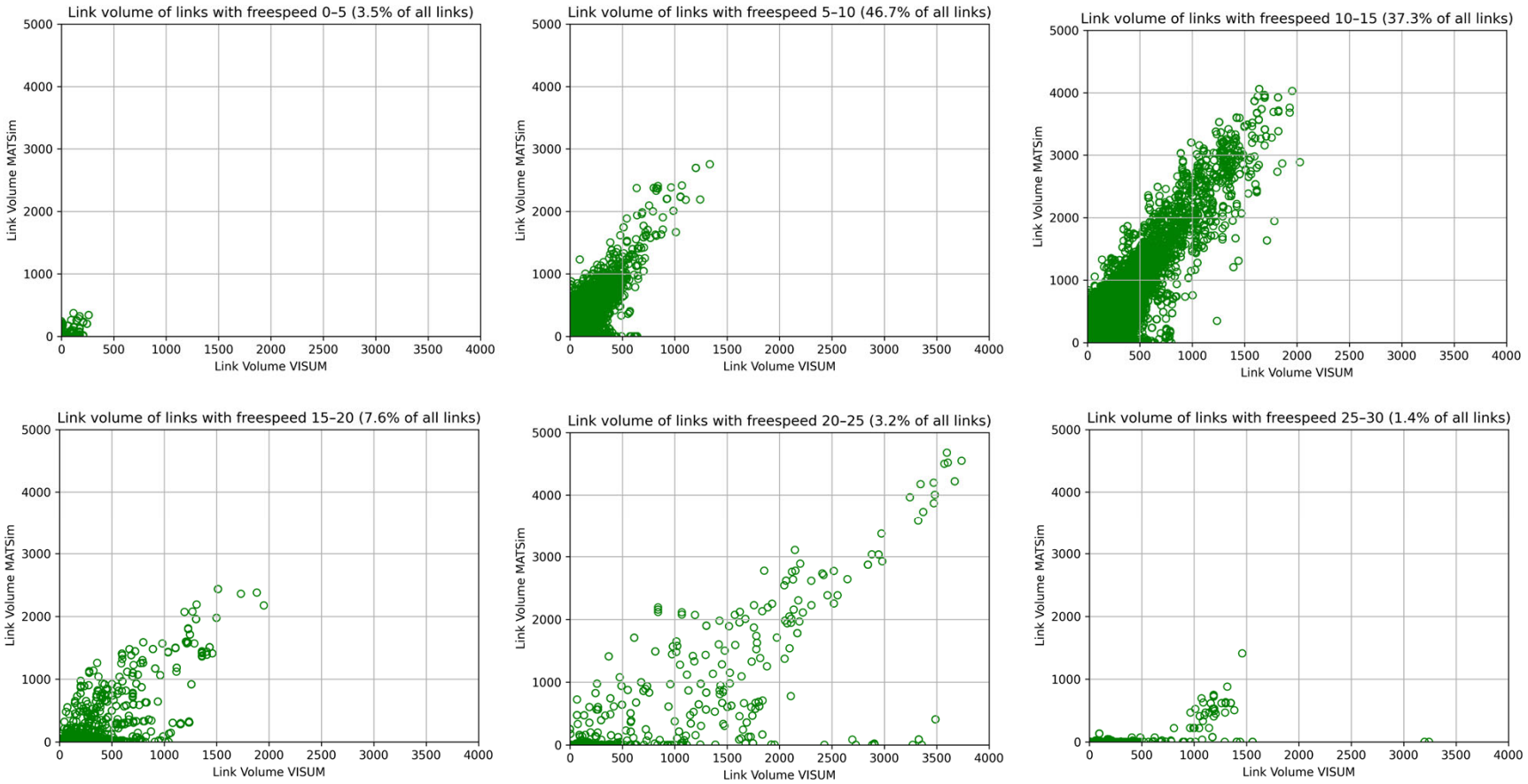



# Comparing link volumes in MATSim to link volumes in VISUM



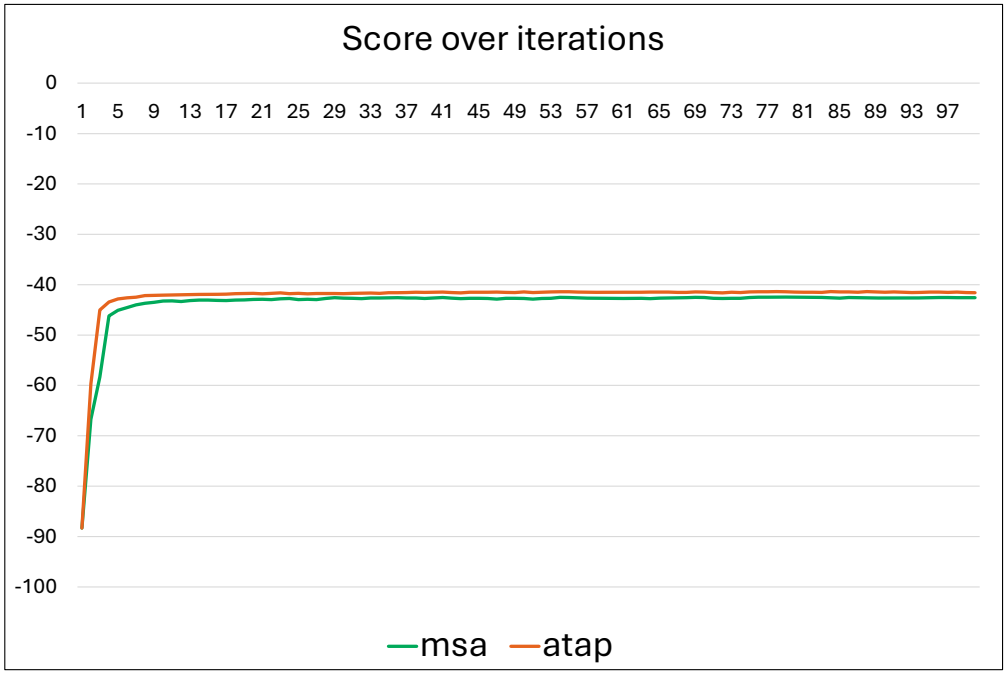
# Comparing link volumes in MATSim to the VISUM model

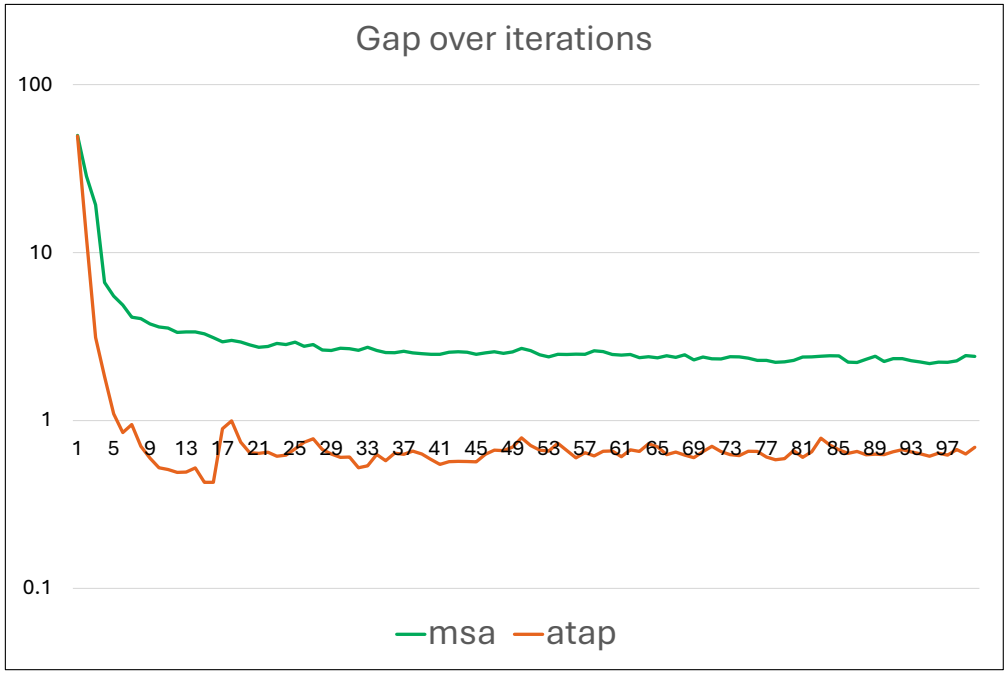


# Summary

- Data reproduction is precise and adjustable
- Population yields plausible simulation results
- Runtime depends largely on spatial resolution and population size
- Successfully transferred VISUM demand to MATSim
  - Spatially disaggregated
  - Enabling dynamic simulation
  - Enabling individual-level analysis

# Digression: Score as a measure for convergence



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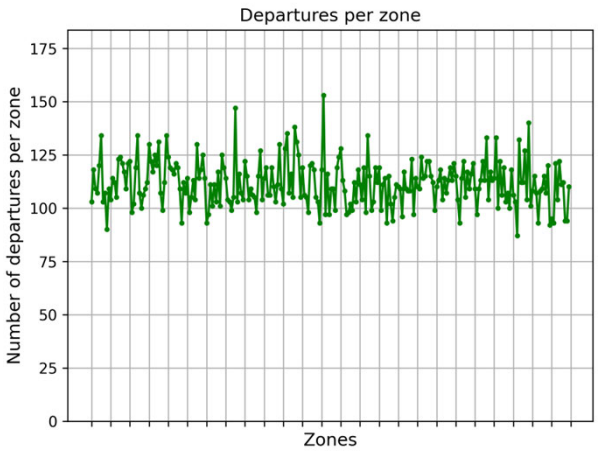
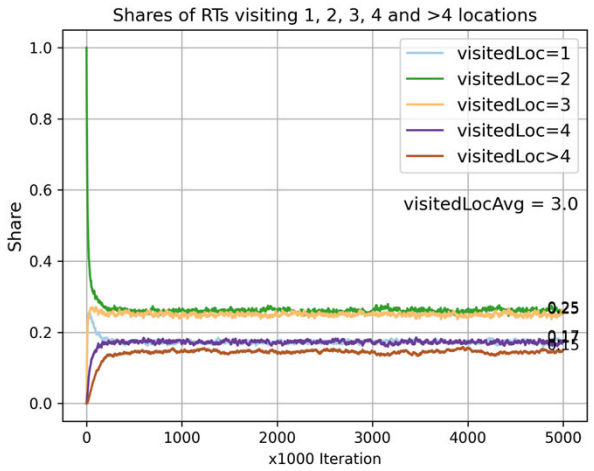
References:
Flötteröd, G. (2025). An operational alternative to origin/destinarion matrices. 13th Symposium of the European Associarion for Research in Transportation, Munich, Germany, 2025

# Prior sampling (no reproduction of data sets)

- Likelihood function:
  - $b(x) \sim e^{-E_{prior}(x)}$

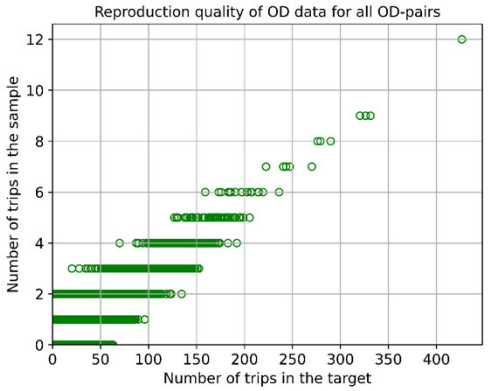


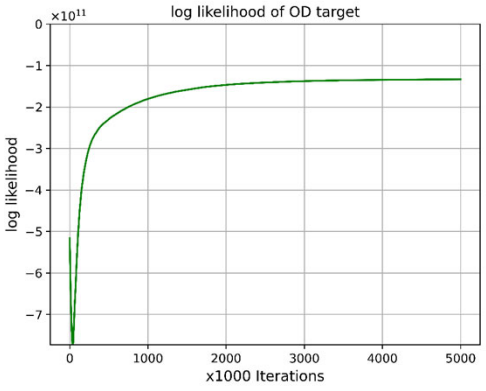


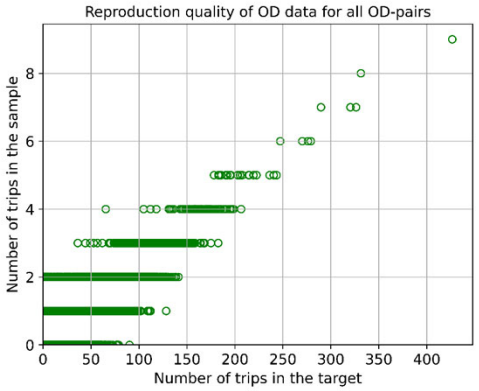


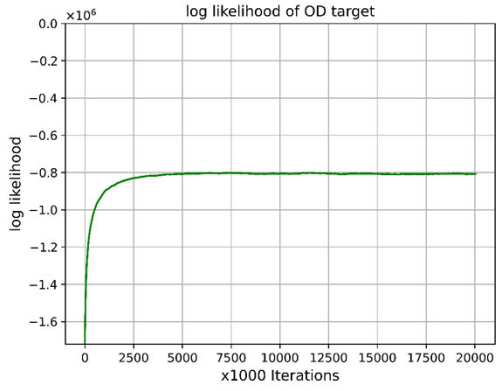
# Using Gaussian distributed sampling weights

- Up to this point, all results were based on sampling weights that were two-sided exponentially distributed
  - $b(x) \sim e^{-[\,\mu \cdot R(x)\,]}$
- Gaussian distributed sampling weight provide some advantages
  - $b(x) \sim e^{-[\,0.5 \cdot \mu \cdot R(x) \cdot R(x)]}$



# Backup slide

- Error function of OD repro:
  - $E_{OD}(x) = \sum_{rs} |t_{rs} - h \cdot s_{rs}|$
    - $t_{rs}$ ... trips from zone $r$ to $s$ in the target OD matrix
    - $s_{rs}$ ... trips from zone $r$ to $s$ in the sample OD matrix
    - $h$ ... scaling factor; $h = \frac{\sum_{rs} t_{rs}}{\sum_{rs} s_{rs}}$

- Population groups:

| | | | |
|---|---|---|---|
| pop group 06 | 19-35 years | working | Car access |
| pop group 07 | 19-35 years | other | Car access |
| pop group 08 | 35-65 years | working | Car access |
| pop group 09 | 35-65 years | other | Car access |
| pop group 14 | >65years | Not specified | Car access |