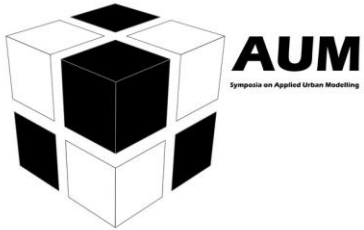
Validating disaggregate models at an aggregate scale:

A case study of mobility tool ownership in Switzerland



Tim Hillel, Janody Pougala, and Michel Bierlaire

Patrick Manser and Wolfgang Scherr

Transport and Mobility Laboratory TRANSP-OR

École Polytechnique Fédérale de Lausanne EPFL

Angebotsplanung

Schweizerische Bundesbahnen SBB AG

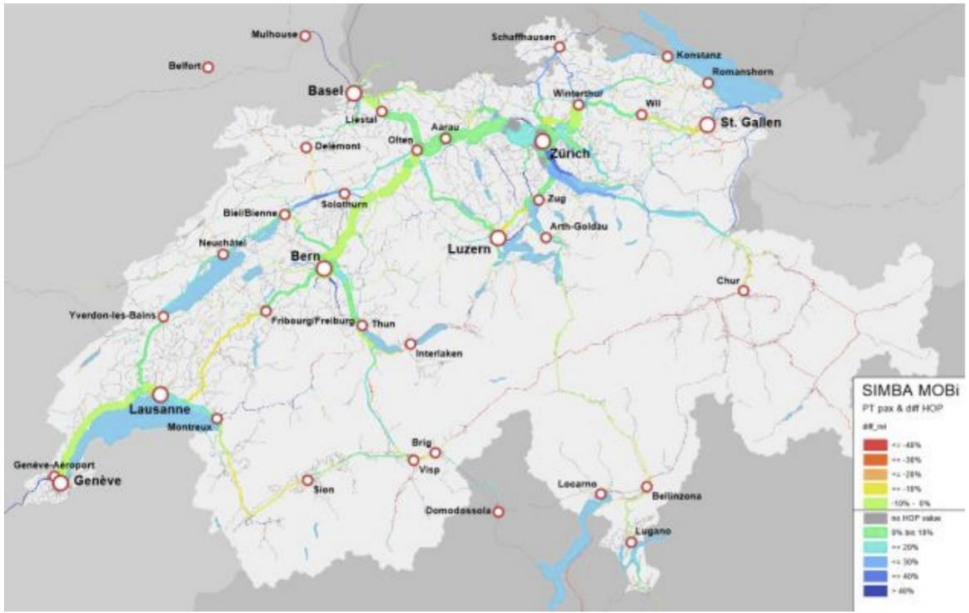
SBB CFF FFS

EPFL

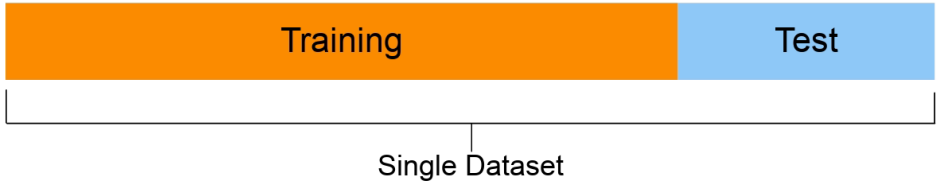
Validation in the era of Agent-based models

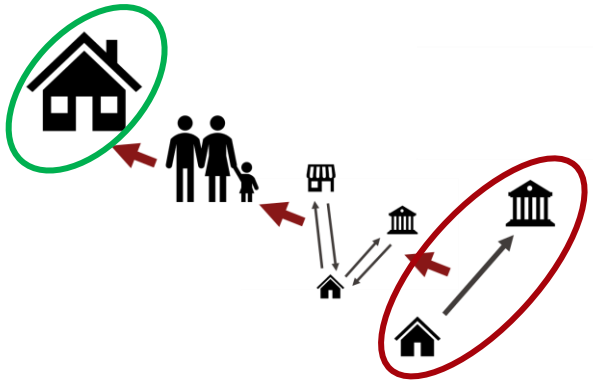
RUM - Hypothesis testing for single choices

ABM - Detailed flows from complex interactions

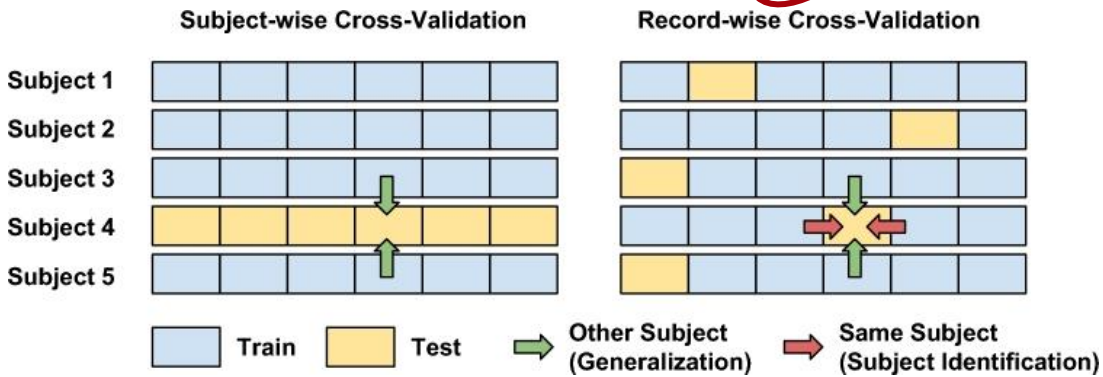


Out-of-sample vs external validation





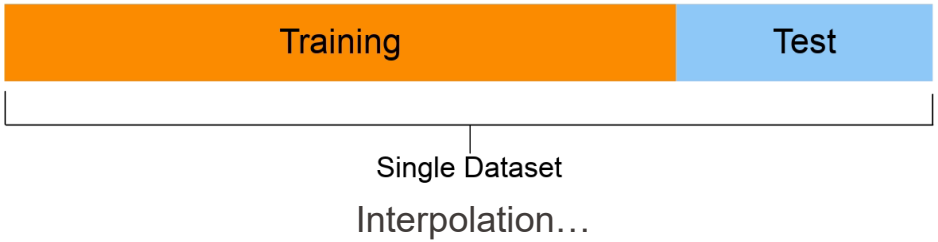
"Of the 45 studies which use hierarchical (panel) data, or data which may be hierarchical, **none** mention the use of grouped (by household or individual) sampling."

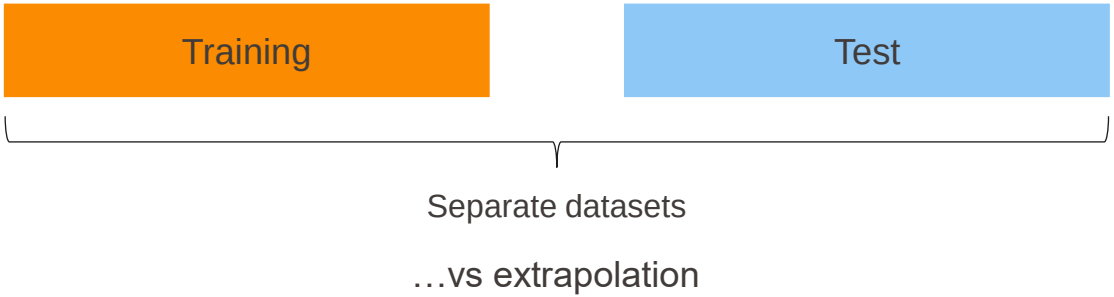


Saeb, S., Lonini, L., Jayaraman, A., Mohr, D. C., & Kording, K. P. (2017). The need to approximate the use-case in clinical machine learning. *Gigascience*, *6*(5), gix019.

Hillel, T., Bierlaire, M., Elshafie, M., & Jin, Y. (2020). A systematic review of machine learning classification methodologies for modelling passenger mode choice. *Journal of Choice Modelling*, 100221.

Out-of-sample vs external validation





Out-of-sample vs external validation

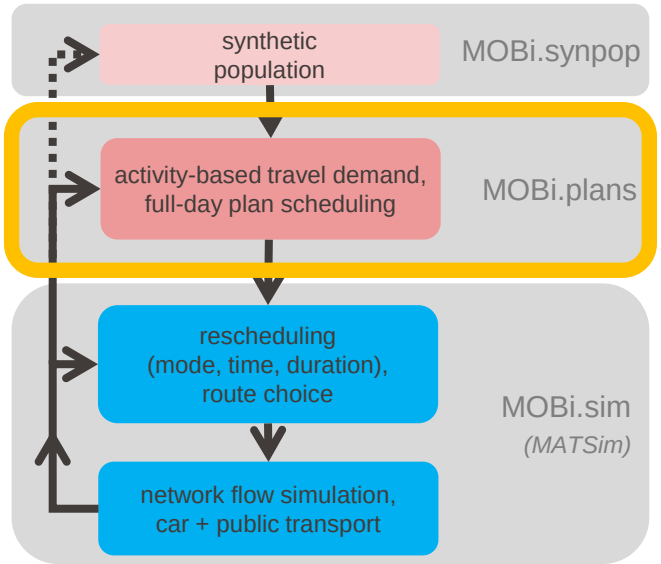
- Fallacy of “out-of-sample” validation
  - Systematic review of ML for mode-choice – all used incorrect validation methods
- Even if done correctly, out-of-sample validation does not represent external validation
- Even when done correctly, external validation does not necessarily simulate the use case
  - Prediction vs forecasting

Travel demand forecasting at SBB

- Swiss Federal Railways (SBB) is continuously developing an operational **multimodal** and **microscopic** nationwide transport model as an extension of the existing rail model
- Model requirements:
  - ability to simulate long-term forecasting scenarios (2040+)
  - representation of transport modes that are **competing with the railway**
  - **door-to-door** simulation of travel (e.g. access to train stations)
  - **future transport modes** (e.g. autonomous vehicles and ridesharing services for *first and last-mile*)
  - detailed representation of **demographic shifts** and **disruptive policies**
- Pioneers in this field, need for more research on various topics

SIMBA MOBi: microscopic travel simulation of Switzerland

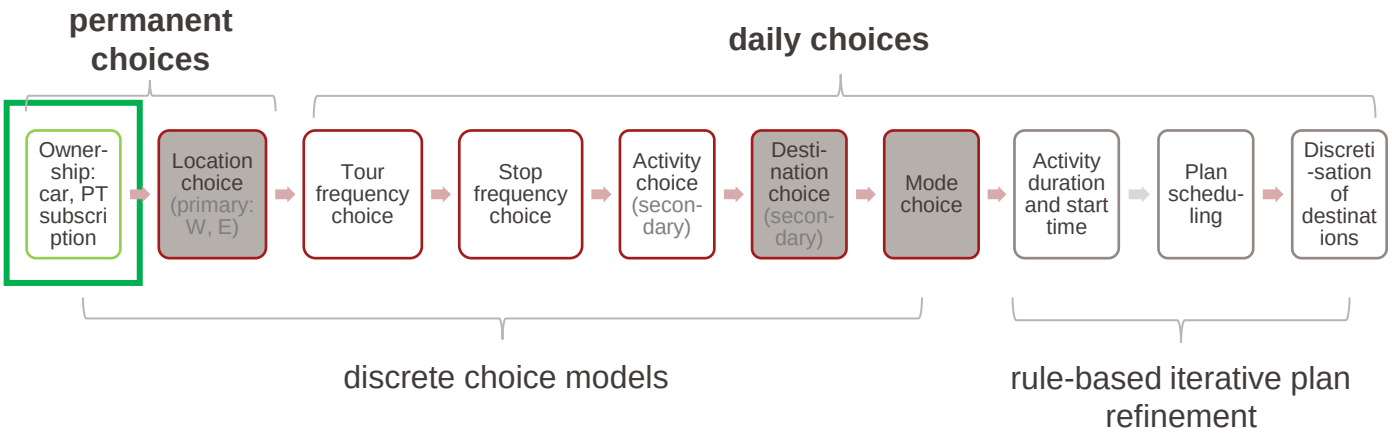
- Full nationwide agent-based simulation model for Switzerland



Scherr W., Joshi C., Manser P., Frischknecht N., and Métrailler D., (2019) “An Activity-based Travel Demand Model of Switzerland Based on Choices and Constraints,” in *8th Symposium of the European Association for Research in Transportation, Budapest*.

MOBi.Plans: microscopic travel devand

- A sequence of 10 steps to construct individual day plans



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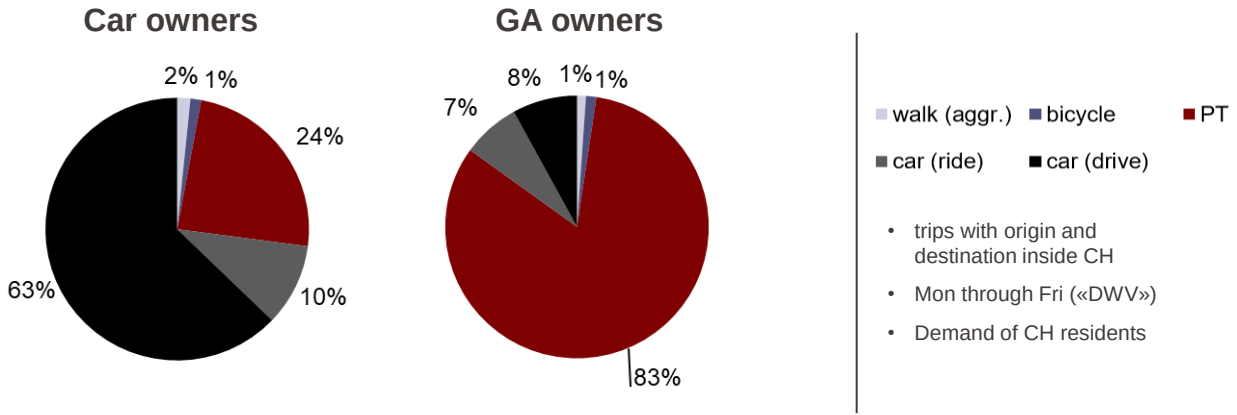
Ownership of mobility tools

- Ownership of mobility tools, including cars and public transport subscriptions, determines individual scheduling and travel behaviour
  - E.g. Activity participation and scheduling, location choice, mode choice
- Decisions made both at **household** level (e.g. **car ownership**) and at **individual** level (e.g. **public transport subscription**)
- Understanding shared mobility resources is key to modelling complex household interactions
  - Essential to predict penetration and demand for **future transport modes** (e.g. autonomous vehicles and ridesharing services from and to the rail stations)

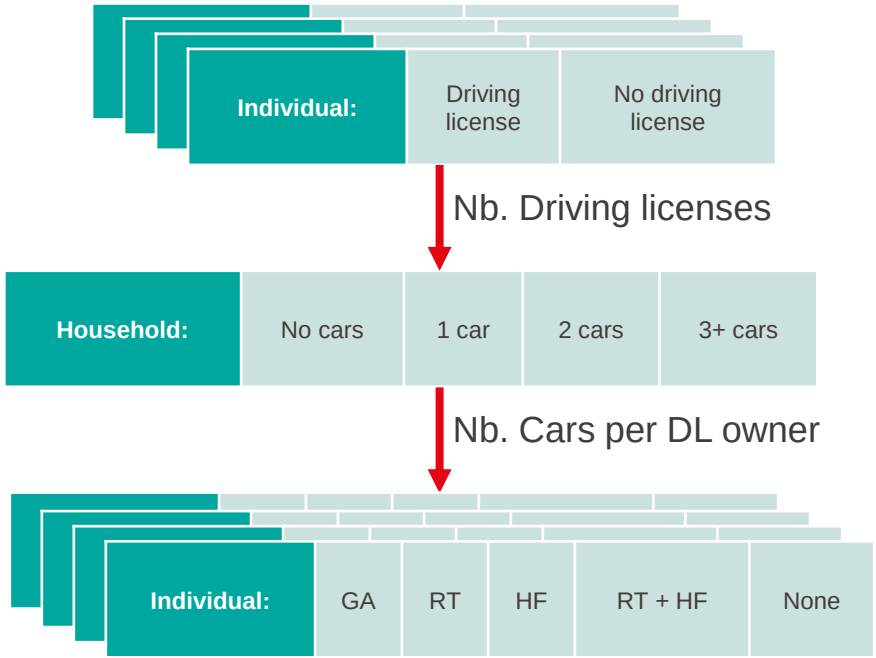
Ownership of mobility tools – impact on behaviour

Person-kilometers by transport mode:

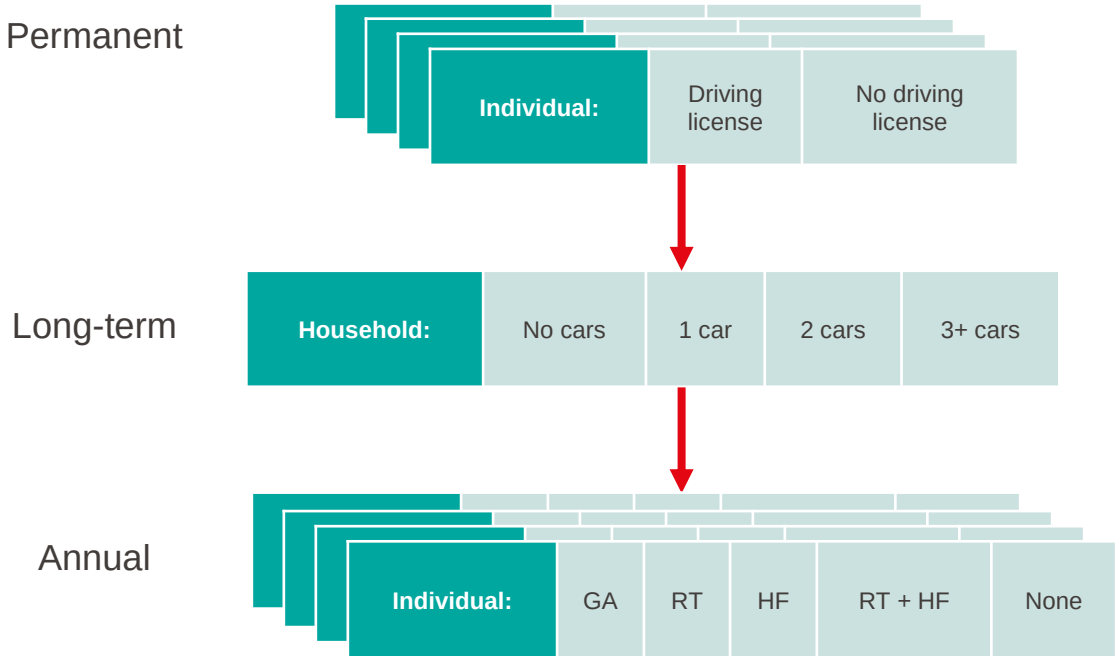


- trips with origin and destination inside CH
- Mon through Fri («DWV»)
- Demand of CH residents

Structure

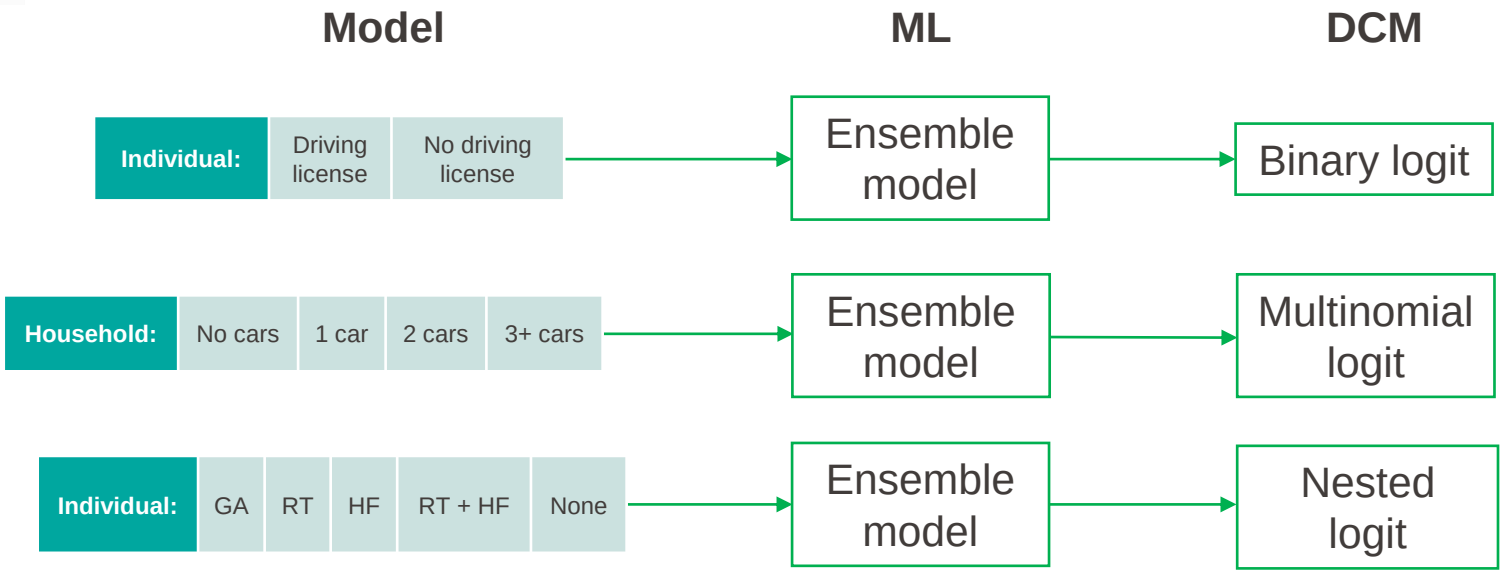

Individual:
Driving license
No driving license
Nb. Driving licenses
Household:
No cars
1 car
2 cars
3+ cars
Nb. Cars per DL owner
Individual:
GA
RT
HF
RT + HF
None

Structure



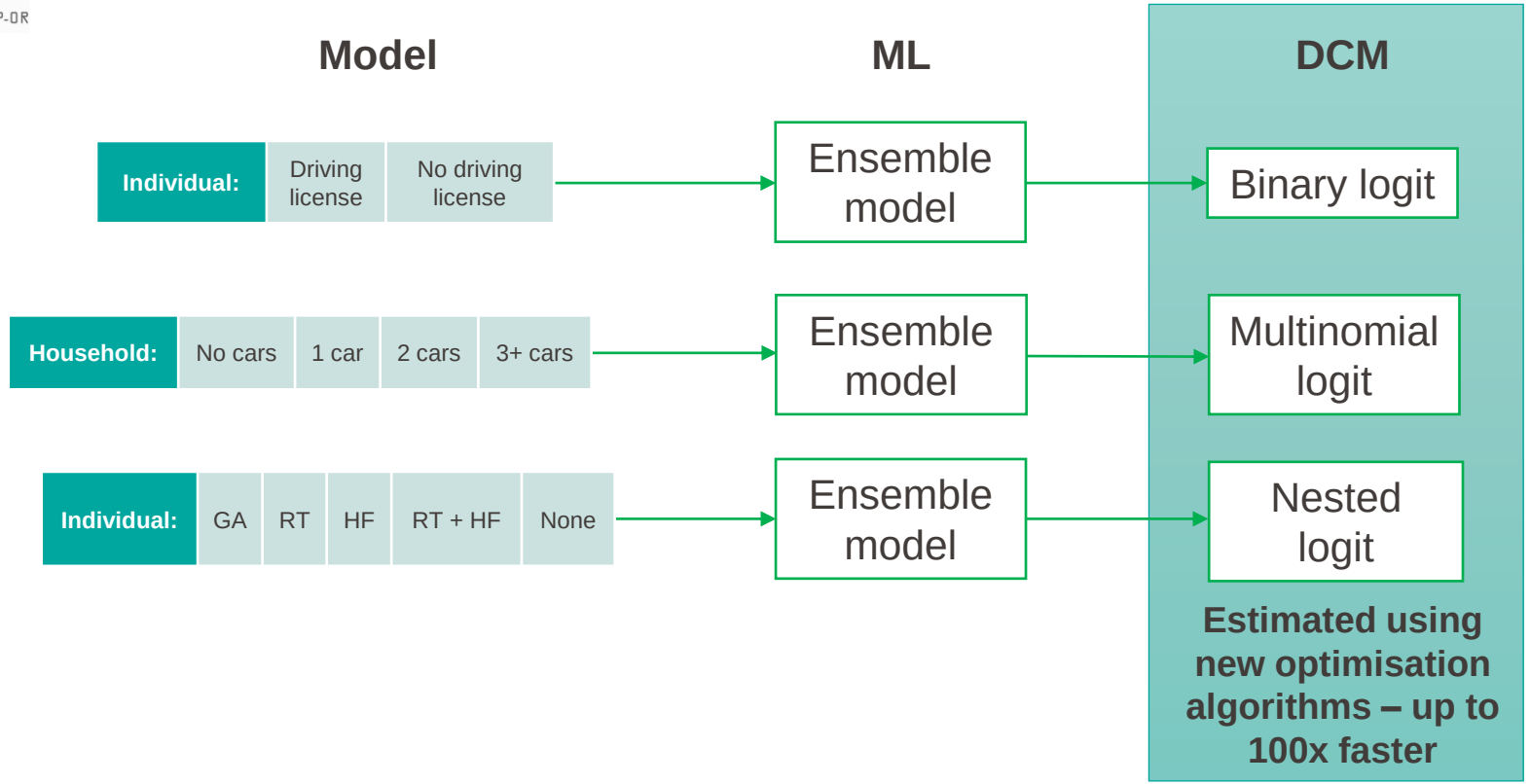
Hillel, T., Pougala, J., Manser, P., Luethi, R., Scherr, W., & Bierlaire, M. (2020). Modelling mobility tool availability at a household and individual level: A case study of Switzerland. In *hEART conference. Lyon, France*.

Machine learning: Assisted specification approach



Hillel, T., Bierlaire, M., Elshafie, M., & Jin, Y. (2019, April). Weak teachers: Assisted specification of discrete choice models using ensemble learning. In *8th Symposium of the European Association for Research in Transportation, Budapest*.

Machine learning: Assisted specification approach

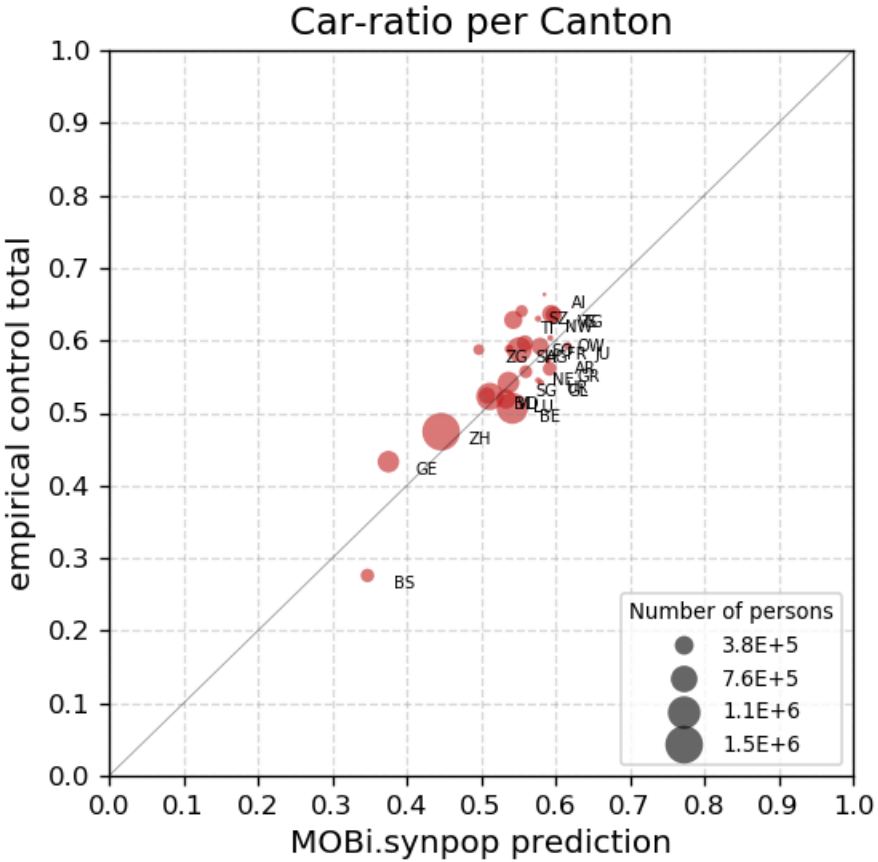


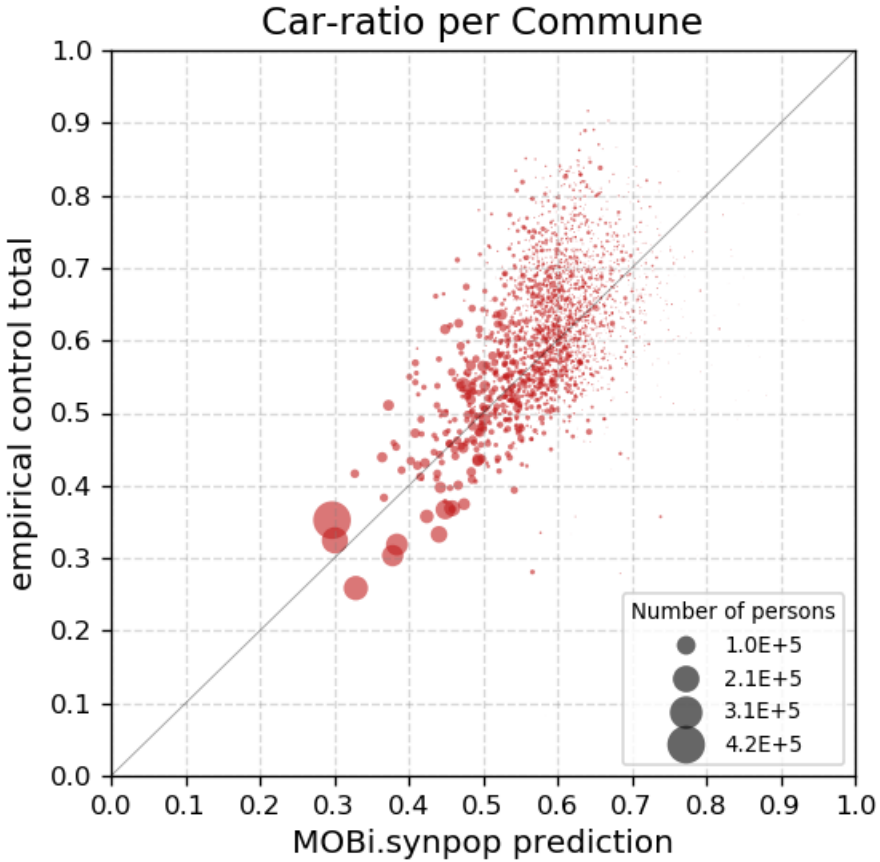
Lederrey, G., Lurkin, V., Hillel, T., & Bierlaire, M. (2019). Estimation of discrete choice models with hybrid stochastic adaptive batch size algorithms. *Journal of Choice Modelling*, *38*, 100226.

Model application and validation

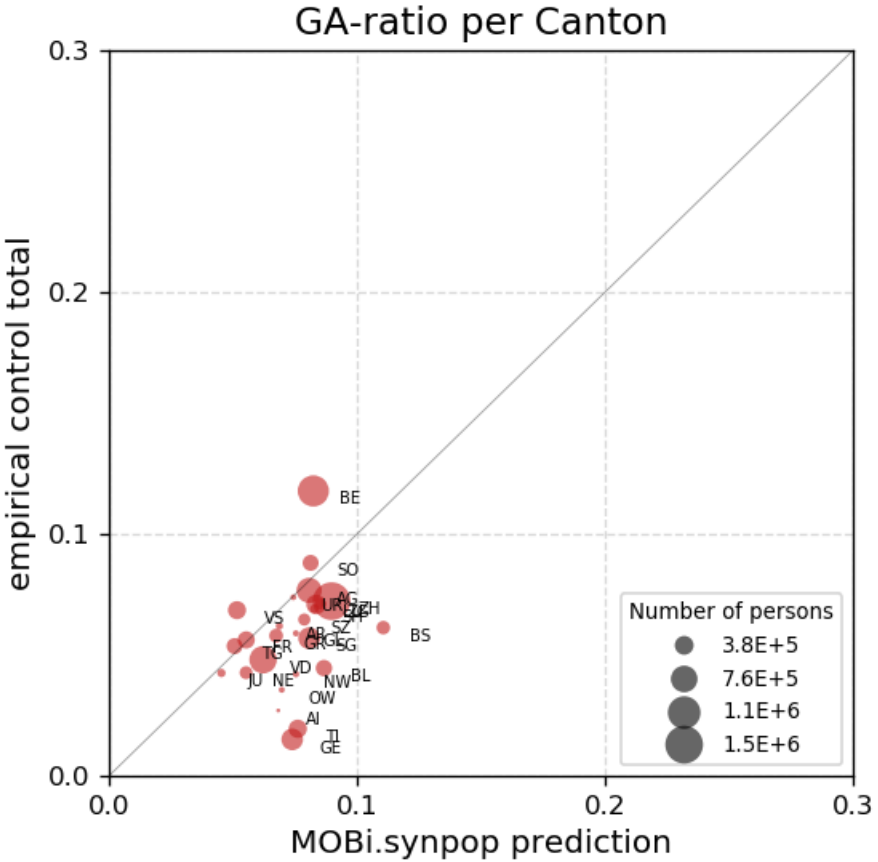
- Model applied to nationwide synthetic population to simulate:
  - Individual level driving license ownership
  - Household level car ownership
  - Individual level public transport subscription
- Predictions validated against control totals at multiple levels of aggregation:
  - Accessibility level (high/medium/low) – 3 groups
  - Cantonal level – 32 groups
  - Municipality level – 2,212 groups
- Recalibration with *shadow constants* at labour market regions (101 groups)

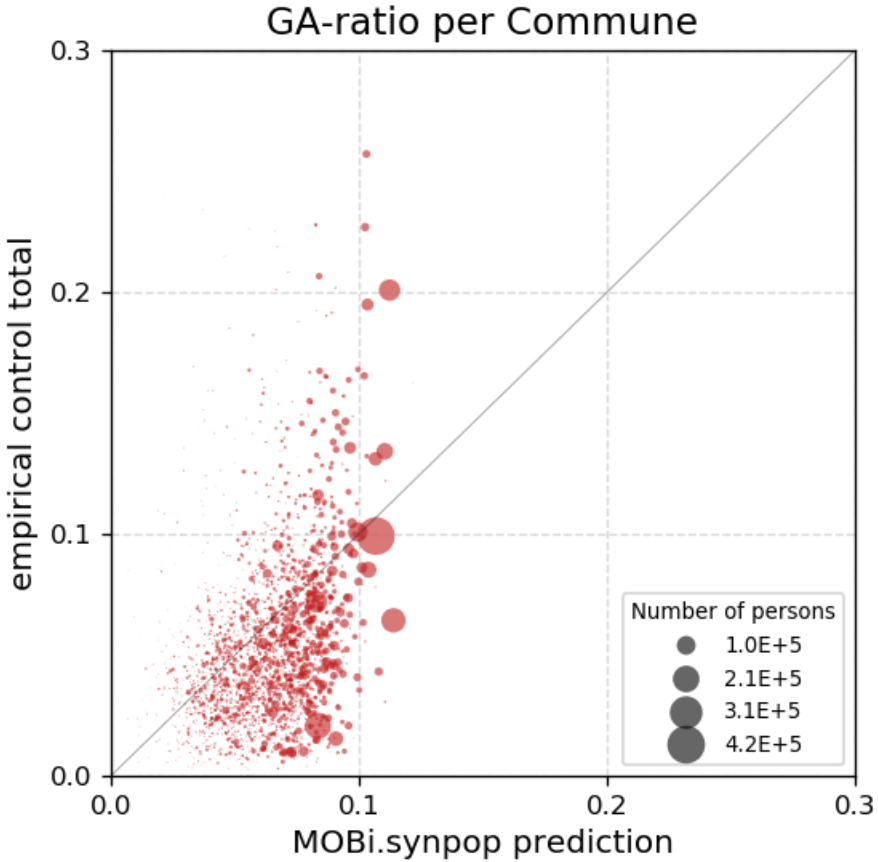
Private vehicle ownership



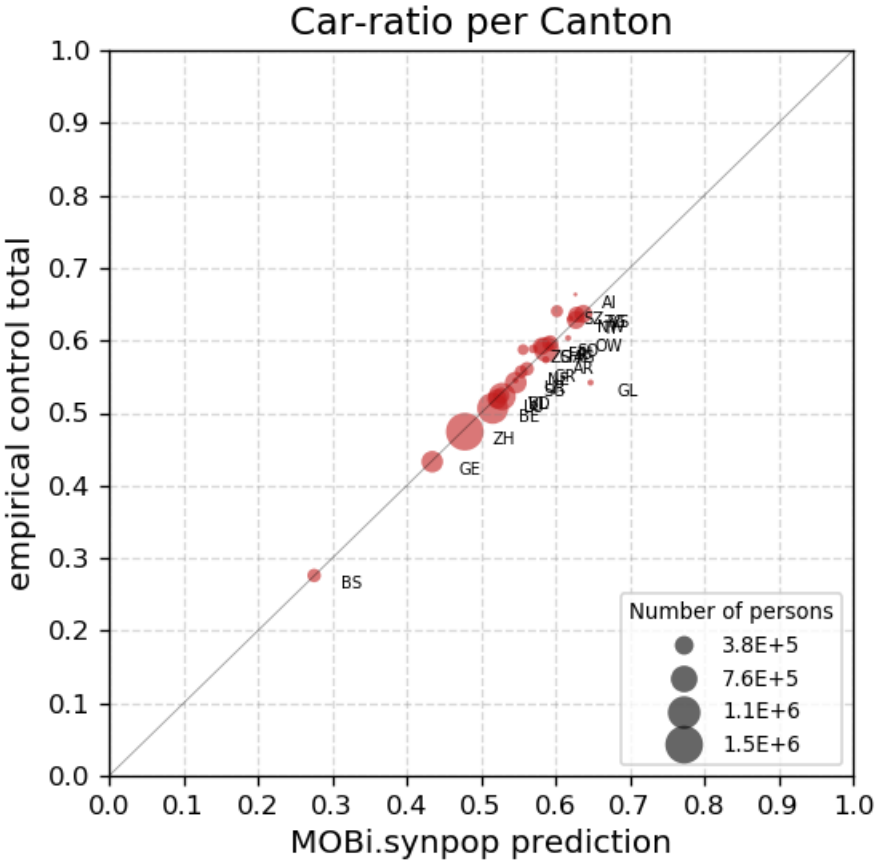


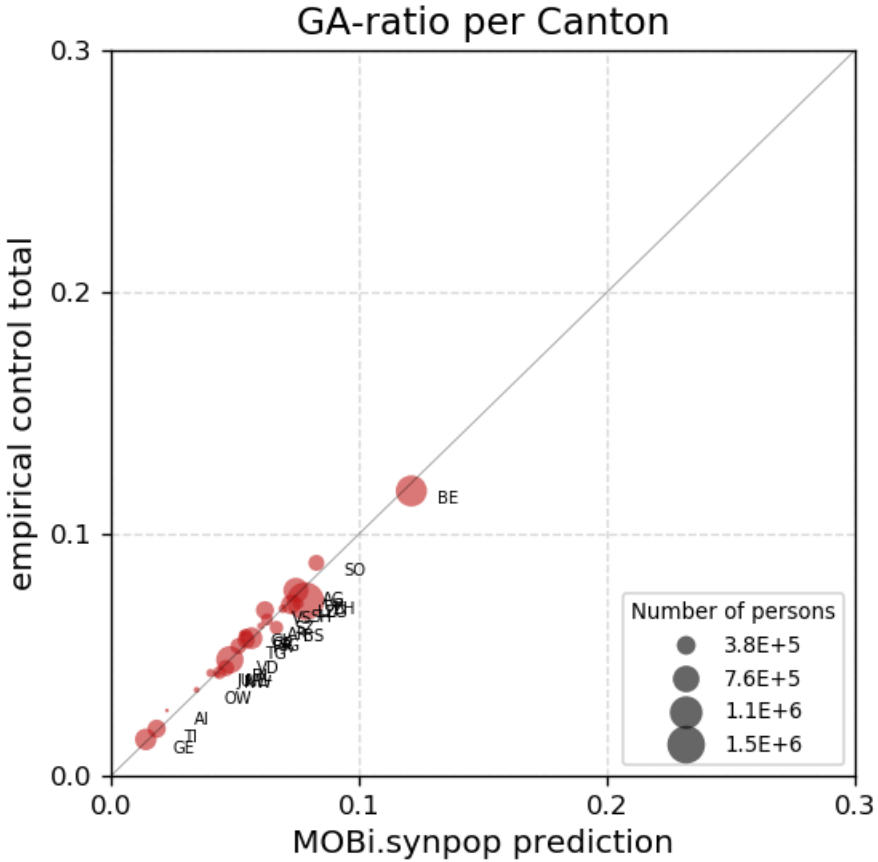
PT subscription



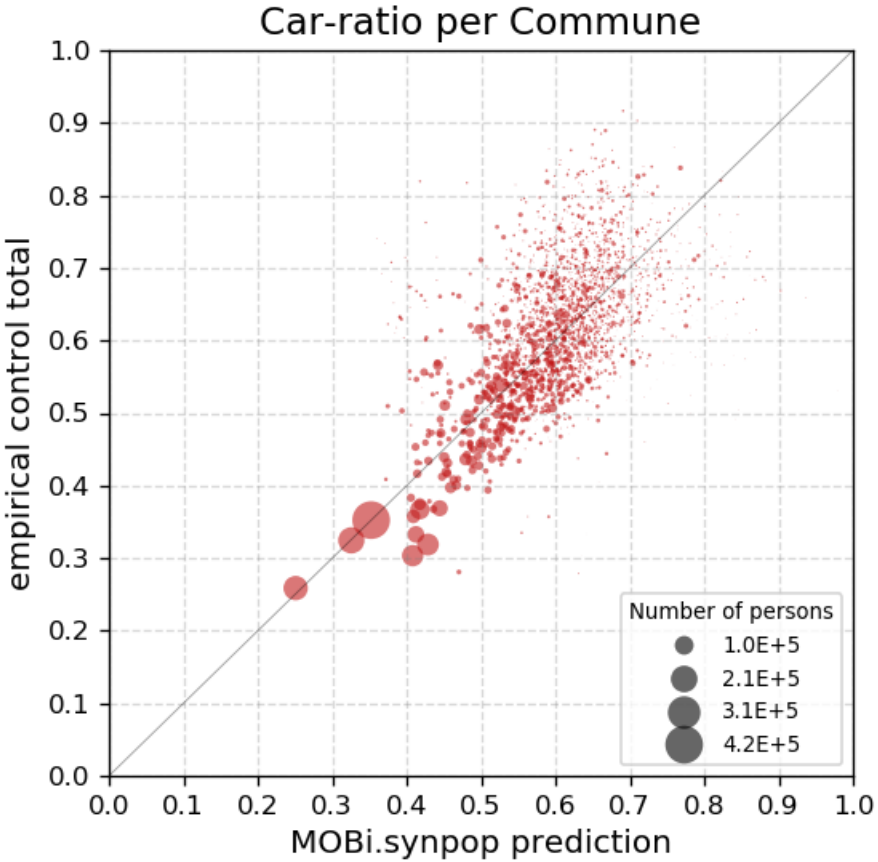


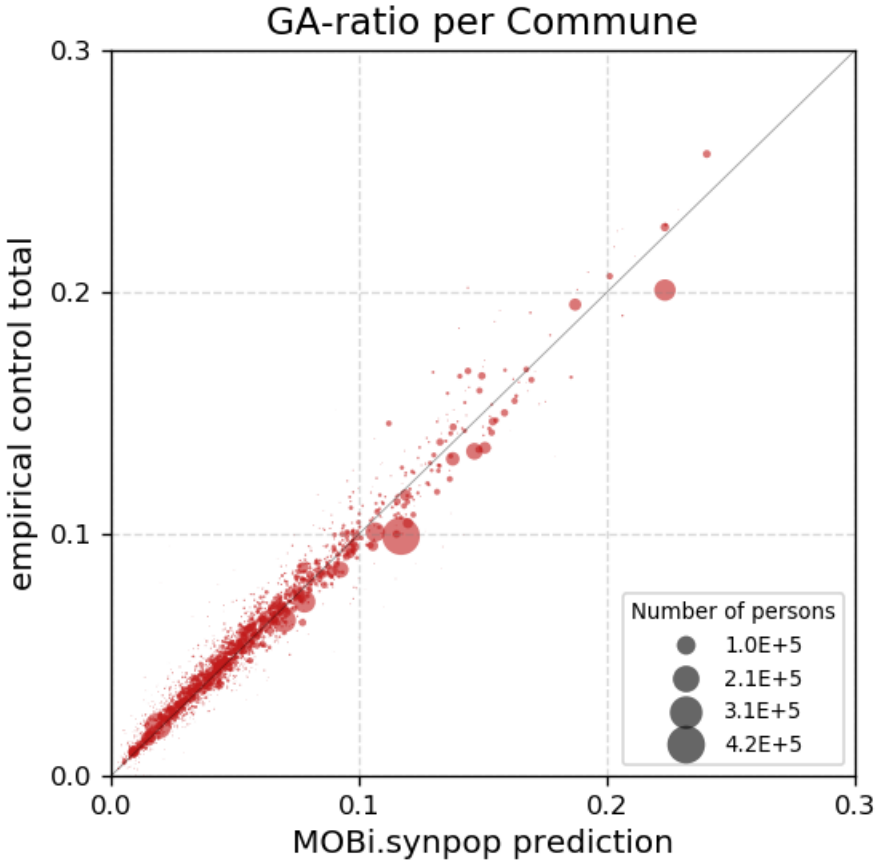
Recalibrated - cantonal level





Recalibrated - municipality level





Conclusions

- Out-of-sample ≠ external ≠ use-case
- Aggregate validation of disaggregate model at multiple scales…
- …BUT:
  - Low dimensional output
  - Categorical data
  - Time invariant
  - Aggregation only in people