Validating disaggregate models at an aggregate scale:
A case study of mobility tool ownership in Switzerland

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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.”


Out-of-sample vs external validation

- Single Dataset
  - Interpolation...

- Separate datasets
  - ...vs extrapolation
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
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

MOBi.Plans: microscopic travel demand

- A sequence of 10 steps to construct individual day plans

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:

- Car owners
  - 63% car (drive)
  - 24% PT
  - 10% car (ride)
  - 7% bicycle
  - 2% walk (aggr.)

- GA owners
  - 83% car (drive)
  - 8% PT
  - 1% car (ride)
  - 1% bicycle
  - 1% walk (aggr.)

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

Individual: 
- Driving license
- No driving license

Household: 
- No cars
- 1 car
- 2 cars
- 3+ cars

Individual: 
- GA
- RT
- HF
- RT + HF
- None

Nb. Driving licenses

Nb. Cars per DL owner
<table>
<thead>
<tr>
<th>Individual:</th>
<th>Driving license</th>
<th>No driving license</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household:</td>
<td>No cars</td>
<td>1 car</td>
</tr>
<tr>
<td>Annual</td>
<td></td>
<td>GA</td>
</tr>
</tbody>
</table>

Machine learning: Assisted specification approach

Machine learning: Assisted specification approach

- **Model**
  - **Individual:** Driving license, No driving license
  - **Household:** No cars, 1 car, 2 cars, 3+ cars

- **ML**
  - Ensemble model
  - **Individual:** GA, RT, HF, RT + HF, None

- **DCM**
  - Binary logit
  - Multinomial logit
  - Nested logit

Estimated using new optimisation algorithms – up to 100x faster

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 \textit{shadow constants} at labour market regions (101 groups)
Private vehicle ownership

Car-ratio per Canton

Car-ratio per Commune

Number of persons
- 3.8E+5
- 7.6E+5
- 1.1E+6
- 1.5E+6

Number of persons
- 1.0E+5
- 2.1E+5
- 3.1E+5
- 4.2E+5
Recalibrated - cantonal level

Car-ratio per Canton

GA-ratio per Canton

Number of persons
- 3.8E+5
- 7.6E+5
- 1.1E+6
- 1.5E+6
Recalibrated - municipality level

Car-ratio per Commune

MOBi.synpop prediction vs empirical control total

GA-ratio per Commune

MOBi.synpop prediction vs empirical control total

Number of persons:
- 1.0E+5
- 2.1E+5
- 3.1E+5
- 4.2E+5
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