Resolving activity-scheduling conflicts based on individual flexibility

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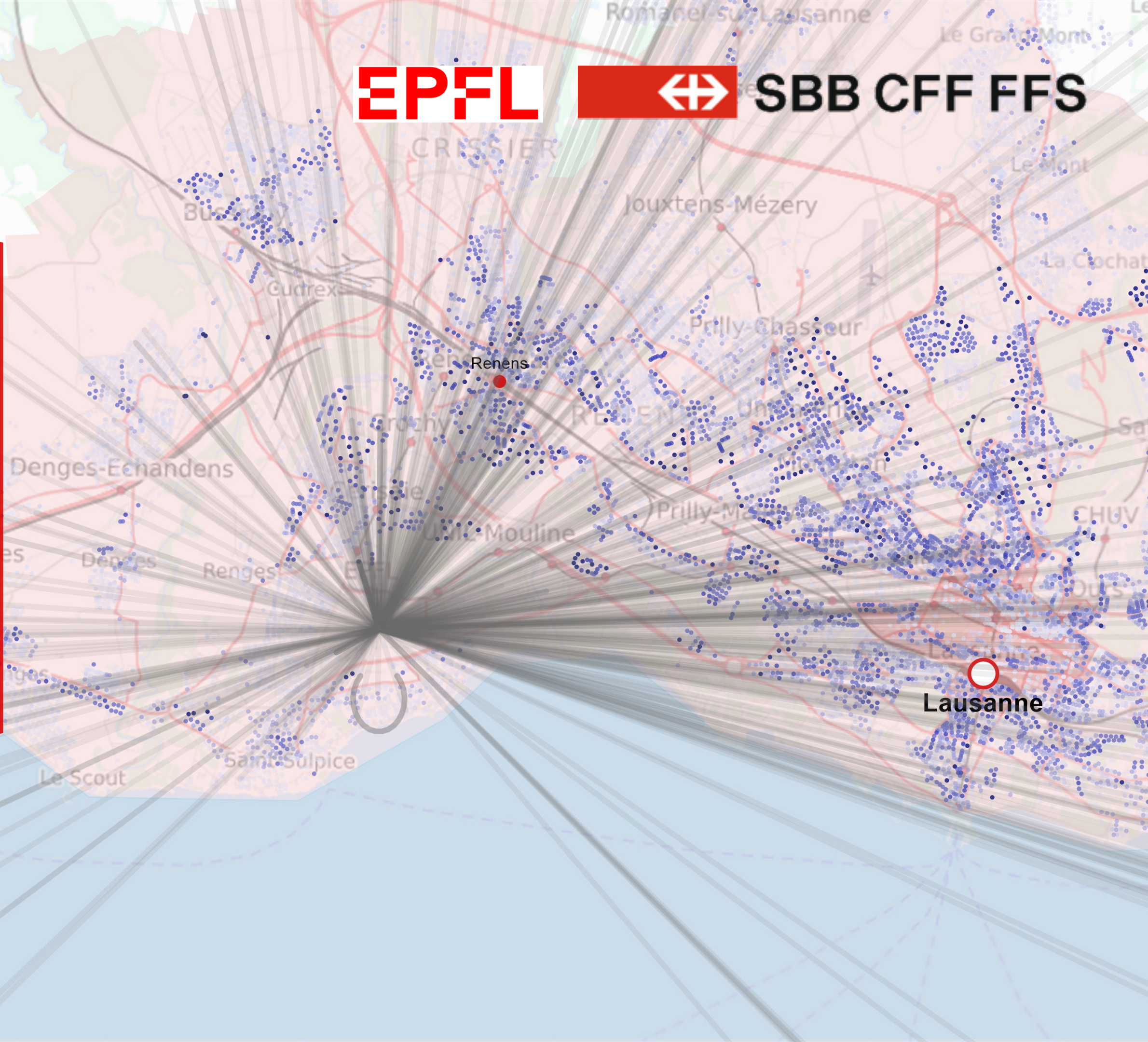


Agenda

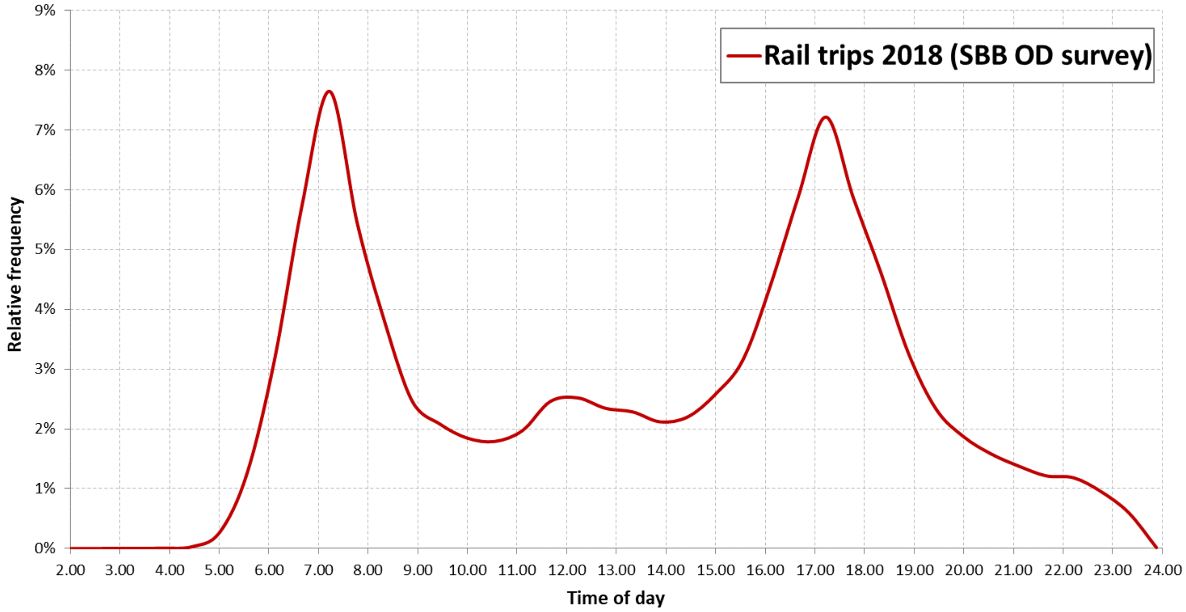
1. Introduction: motivation & project overview
2. A novel framework to resolve activity-scheduling conflicts
3. Case study: full-time workers of Lausanne
4. Conclusion

1. Motivation & project overview

Transport modelling at SBB

→ Aid for mid-term (2025) and long-term (2040/50) **investment decisions**:
  - service planning
  - fleet and infrastructure planning
  - financial planning
  - corporate strategy

→ **Microscopic model SIMBA MOBi** is applied and integrated into planning processes



Collaboration between EPFL and SBB

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

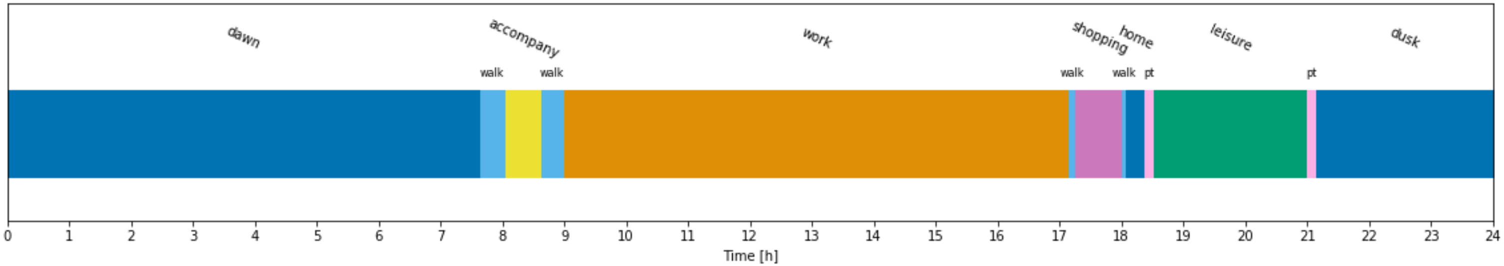
Swiss Confederation

Innosuisse – Swiss Innovation Agency

- Project "*Optimization of individual mobility plans to simulate future travel in Switzerland*" funded by Innosuisse started in Sept. 2020.
- Goal: Improve **predictive performance of SIMBA MOBi**
- Key to success in this collaboration:
  - EPFL and SBB are jointly working on **the same problem** (very regular update meetings)
  - EPFL (Janody Pougala, Tim Hillel & Rico Krueger) develop theoretical framework which is **flexible and easily extendable**
  - SBB **combines the new methodology with existing model components** of SIMBA MOBi, step by step

Activity-based model in SIMBA MOBi

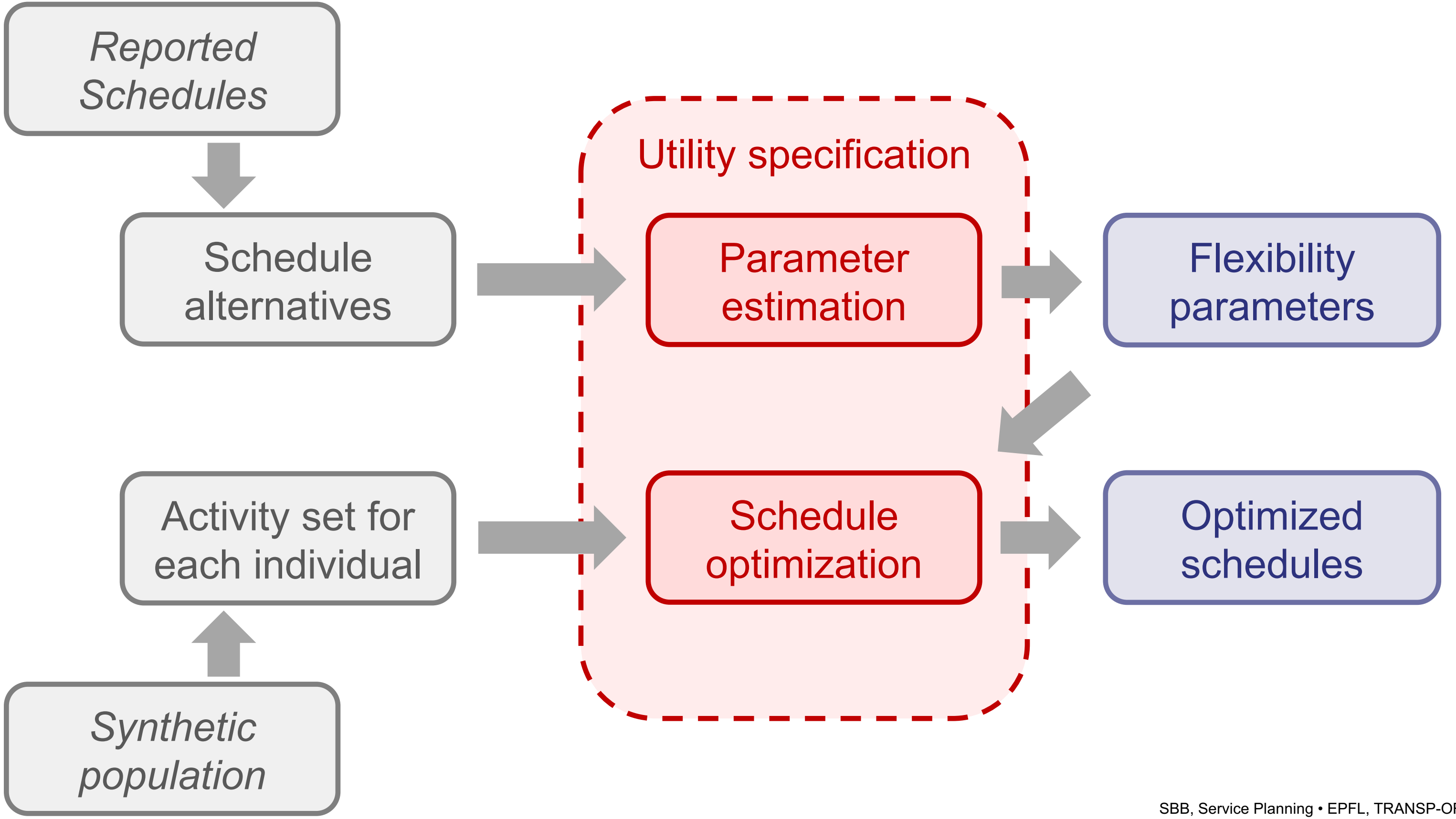
- Model that solves the **daily activity-scheduling problem** for each individual:



- **Existing approach at SBB**: choice dimensions (number of activities, time of day, mode…) are treated **sequentially** using discrete choice models
- **Presented novel approach**:
  - **Optimization program** that treats choices in the **temporal dimension simultaneously**
  - **Non-temporal decisions** are made based **on existing discrete choice models**
  - Solves scheduling conflicts (overlapping activities) according to **utility-maximizing principles** depending on **flexibility parameters**

2. A novel framework to resolve activity-scheduling conflicts

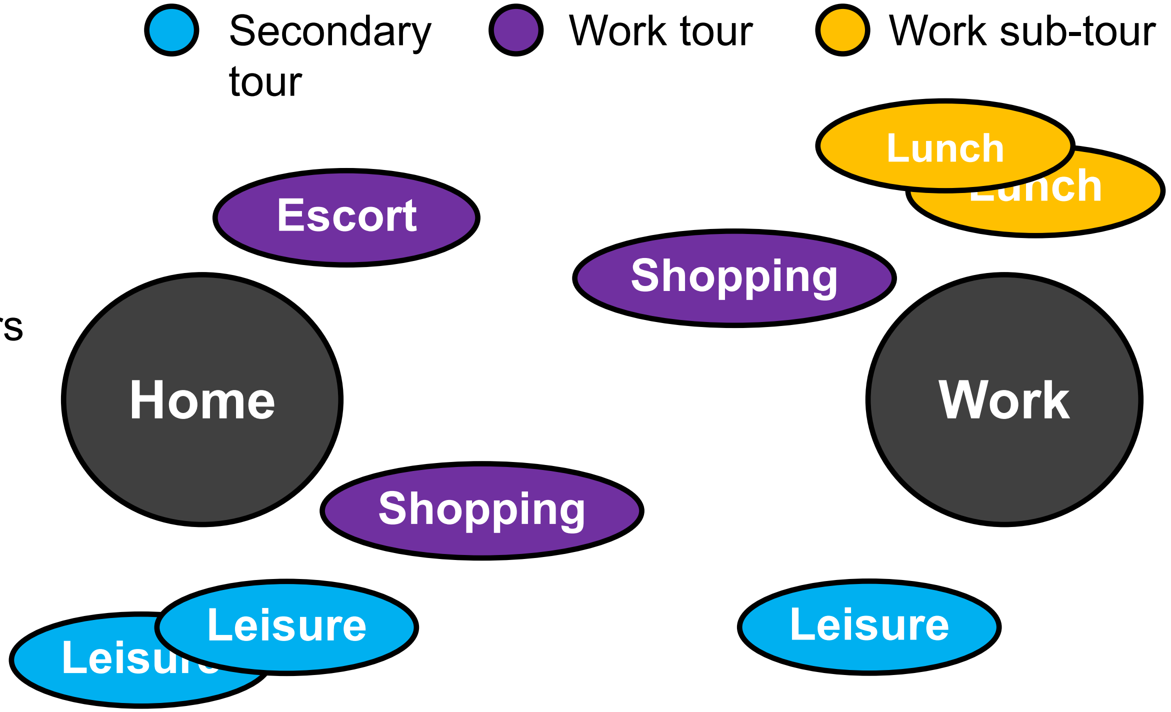
General structure



Non-temporal choices – static input for this study

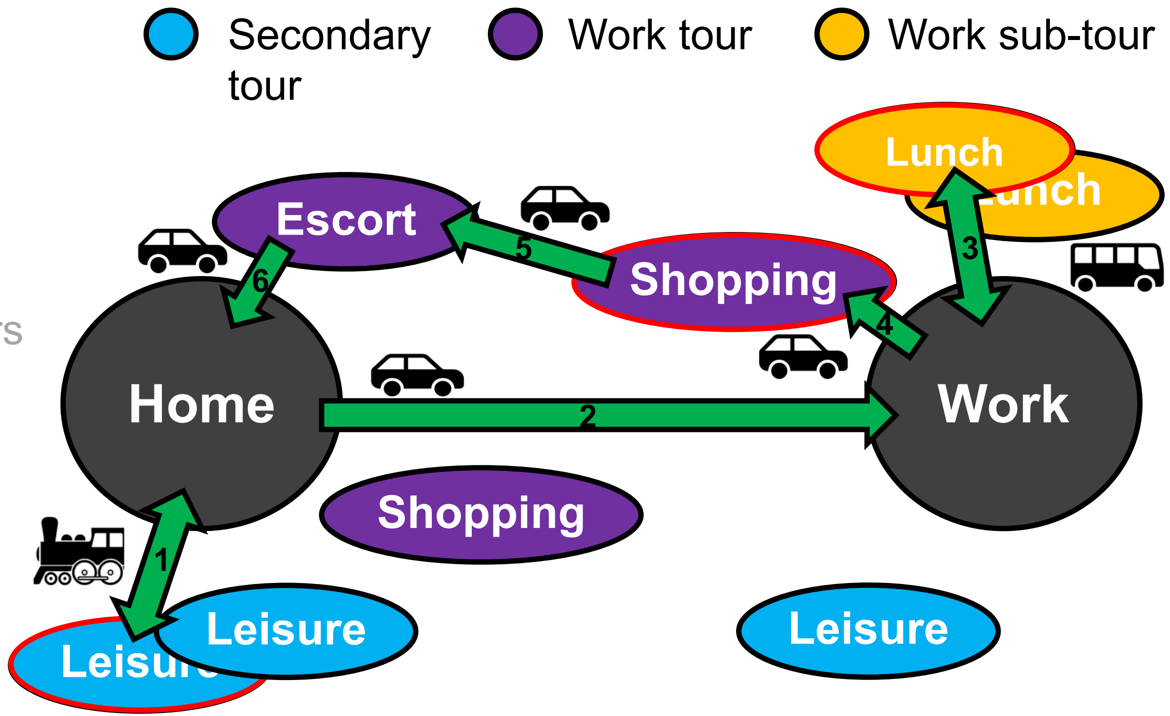
→ **Sequential SIMBA MOBi model**:

- Number and type of activities
- Considered locations
- Number and type of tours



Temporal choices – simulated in this framework

- **Sequential SIMBA MOBi model**:
  - Number and type of activities
  - Considered locations
  - Number and type of tours
- **Simulated choice dimensions**:
  - Start time
  - Duration
  - Location & mode (travel times)



Utility specification

- Used for **estimation** and **optimization program**
- x_a = **start time** of activity *a* τ_a = **duration** of activity *a*

$$\boxed{U_i = \sum_{a \in \mathcal{A}_i} U_{\text{timing}}(x_a) + \sum_{a \in \mathcal{S}_i} U_{\text{duration}}(\tau_a) + \sum_{a \in \mathcal{A}_i \setminus \{\text{dusk}\}} U_{\text{tt},a}(tt_a)}$$

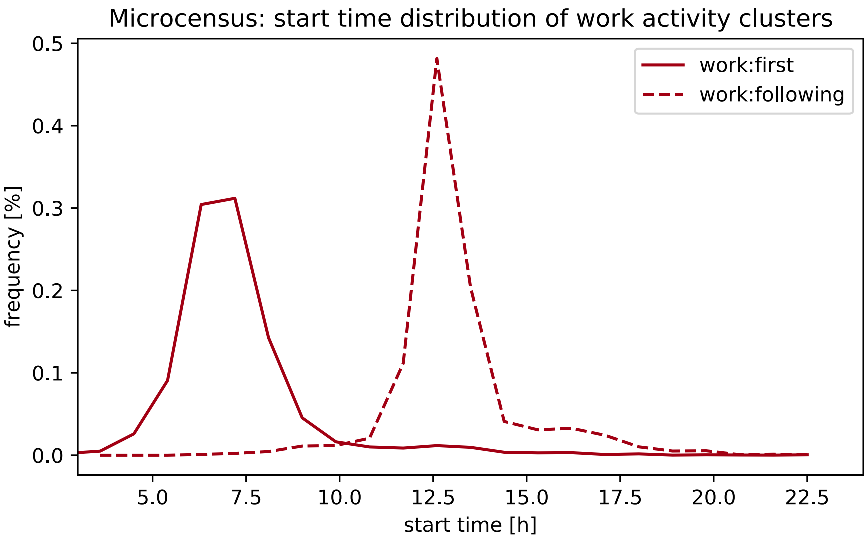
$$U_{\text{timing}}(x_a) = \beta_a^{\text{early}} \max(0; x_a^* - x_a) + \beta_a^{\text{late}} \max(0; x_a - x_a^*)$$

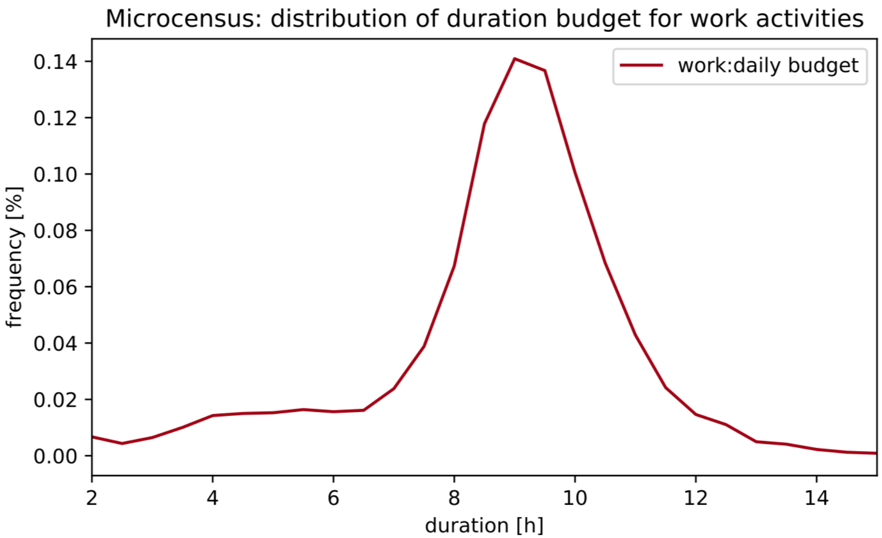
$$U_{\text{duration}}(\tau_a) = \beta_a^{\text{short}} \max(0; \tau_a^* - \tau_a) + \beta_a^{\text{long}} \max(0; \tau_a - \tau_a^*)$$

Flexibility parameters Desired start times and durations

3. Case study: full-time workers of Lausanne

Desired start times and durations





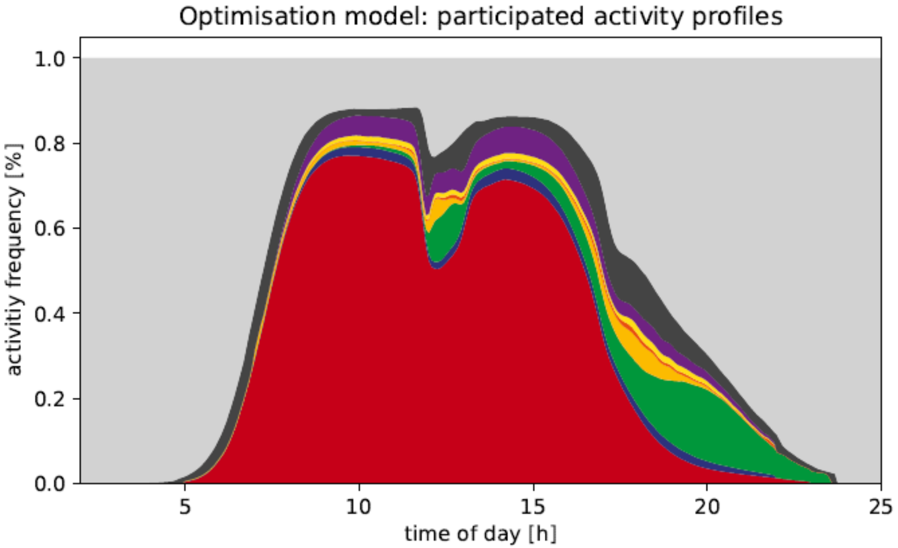
Activity	**Sub-activity** indicator	**Description**	**Avg. occurrence** per schedule	**Des. timing x^* [h]** mean	std	**Des. duration τ^* [h]** mean	std
	p_1	first in set	0.80	7.4	0.9		
work	$p_2, \ldots, p_n$	following	0.31	13.2	0.3		
	$\sum_{a \in \mathcal{P}} \tau_a$	duration budget				9.5	0.5

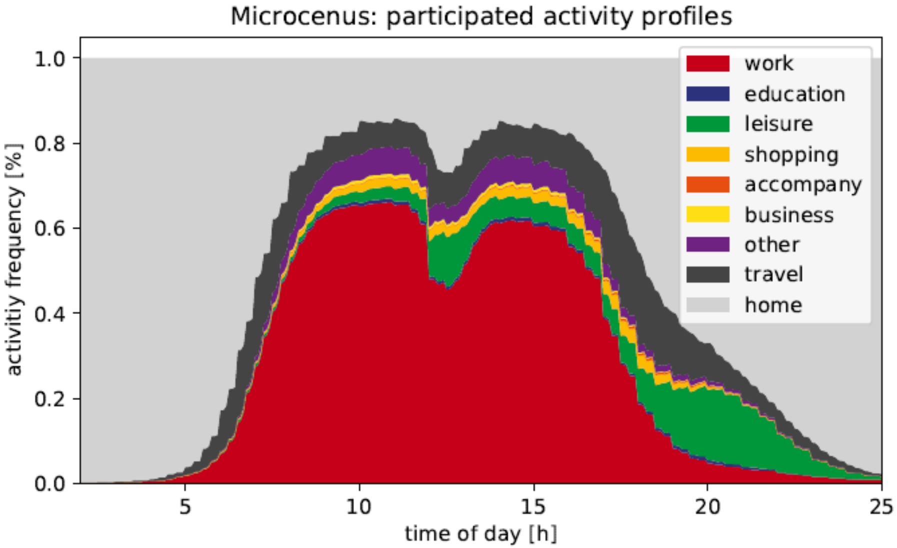
Quantifying flexibility

- → **Maximum likelihood estimation** of a logit model using Biogeme
- → **Alternatives** are generated based on draws from existing sequential SIMBA MOBi model

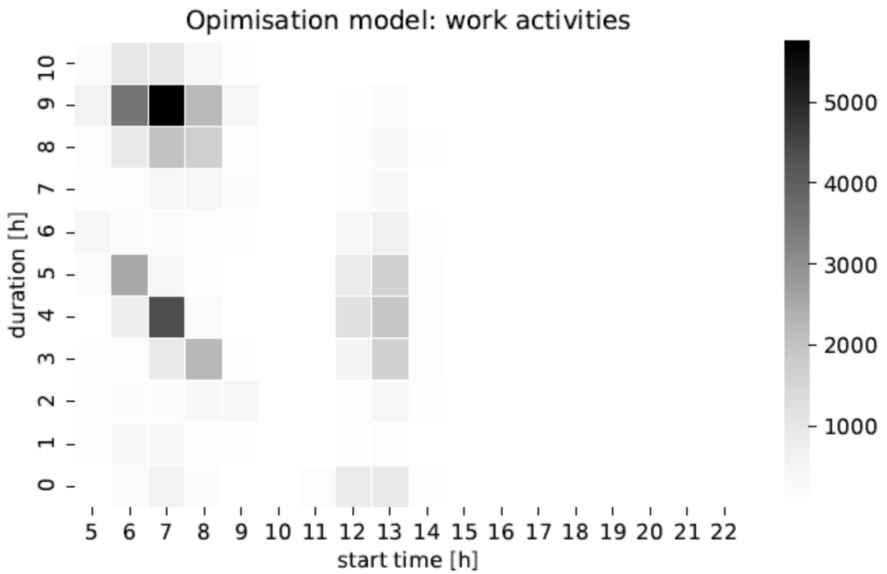
Activity type	Parameter values			
	β_a^{early}	β_a^{late}	β_a^{short}	β_a^{long}
work:first in set	-0.615	-0.436		
work:following	-0.406	0		
work:duration budget			-0.022	0
leisure:lunch	-1.610	-0.821	-7.550	-1.360
leisure:work tour	-0.195	0	0	0
leisure:secondary tour	-0.076	0	-3.060	-0.692
leisure:no primary activity	-0.053	0	0	-0.588
home:lunch	-2.040	-0.929		
home:after work	-0.073	-0.596		
home:no work	0	-0.198		
home:duration budget			0	-0.354

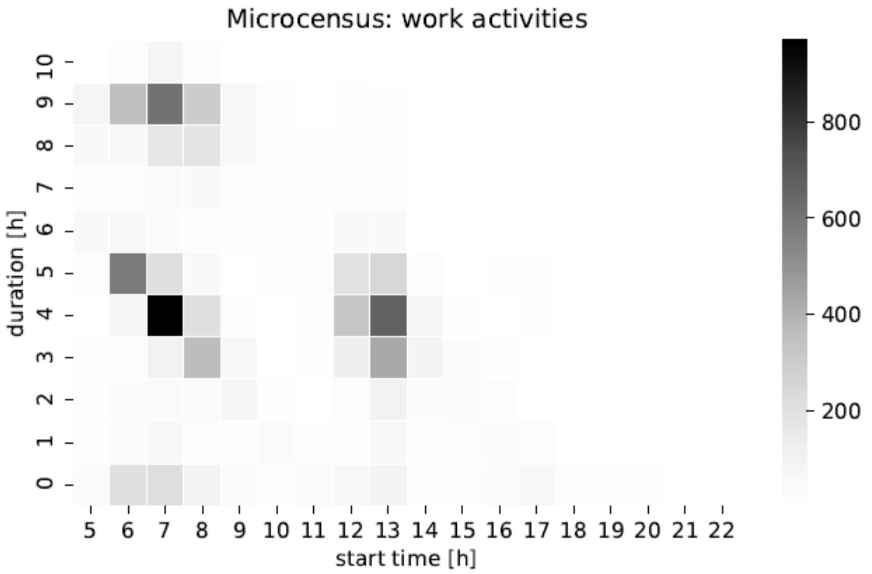
Activity profiles for full-time workers in Lausanne





Work: correlation between start time and duration





3. Conclusion

Conclusion

→ Efficient coupling of new methodical framework with existing discrete choice models:

- Temporal dimension: **Utility maximization** depending on individual **flexibility parameters** (calibration with **maximum likelihood**; simulation with **MILP**)
- Non-temporal choices: **Draws from existing SIMBA MOBi model**

→ **Application** for full-time workers of the city of Lausanne

→ **Further work**:

- Improve performance of the optimization procedure
- Integration of level of service per mode into parameter estimation
- Sensitivity testing
- Generation of schedule alternatives

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