

From one-day to multiday activity scheduling: Extending the OASIS framework

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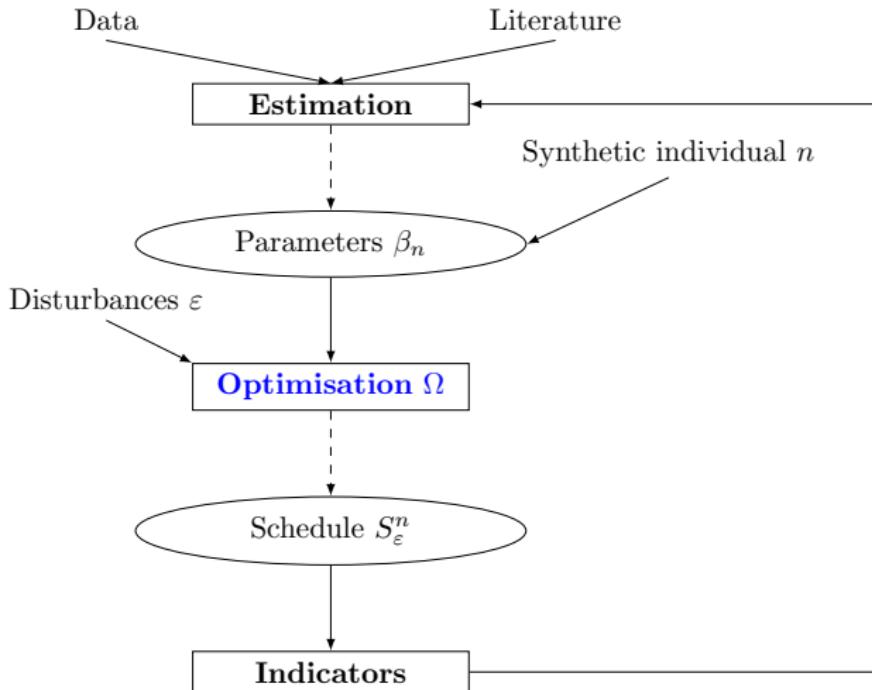
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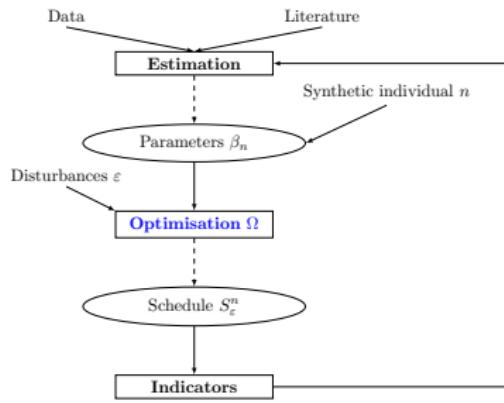


OASIS framework



(Pougala et al., 2022)

OASIS framework



- **Optimisation-based Activity Scheduling Integrating Simultaneous choice dimensions**

- Activity participation, scheduling, mode, location choice
- Explicitly capture **trade-offs** between choices
- Combine econometric and rule-based approaches
- **Single day scheduling**

Multiday vs. single day scheduling

- Single day models are not able to capture intrapersonal interactions (Roorda and Ruiz, 2008; Calastri et al., 2020)
- Multiday behavioural mechanics are mostly latent (Bierlaire et al., 2021):
 - Daily preferences
 - Past scheduling decisions (e.g. **habits**)
 - Future scheduling decisions (**forward-looking planning**)
 - Change of external conditions over time
- Difficult to find appropriate data

Hypotheses

- **Preferences:** preferred day for participation d_a^* , frequency f_a^* day specific desired start time $x_{a,d}^*$ and duration $\tau_{a,d}^*$,
- **Objective function:** weighted sum of day-specific utility functions U_S^d (multiobjective optimization):

$$\Omega = \max_{\omega, z, x, \tau} \sum_d w_d U_S^d$$

- **Decision variables:** vectors of size $D \times 1$: ω, z, x, τ .
- **Daily weights:** Individual-specific priority between days (e.g. weekdays vs. weekend).

Model update

Feature	Single day	Multiday
Time horizon T	1 day	d days
Objective function	Schedule utility U_S	Multi-objective $\sum_d w_d U_S^d \forall d \in T$
Decision variables	Specific to activities	Specific to days and activities
Constraints	Specific to activities	Specific to days and activities
Preferences	Start time, duration	Day, start time duration, frequency

Table: Methodological differences between single-day and multiday framework

Experimental protocol

① Prepare input from travel diary

- Activities (home, work, education, leisure, shopping)
- Individual observed characteristics
- Individual latent characteristics (preferences)

② (Parameter estimation)

③ Simulation of daily schedules

- Weekdays only,
- Weekends only,
- Weekdays and weekends (with and without weights)

Models

- Model 1 (benchmark): single day model ran multiple times, with **day-specific** preferences:

$$U_S^d = \sum_{a=0}^A \omega_{a,d} (U_{a,d}^{\text{participation}} + U_{a,d}^{\text{start time}} + U_{a,d}^{\text{duration}}) + \sum_{a=0}^A \sum_{b=0}^A z_{ab,d} (U_{ab,d}^{\text{travel}}).$$
$$\forall d \in T$$

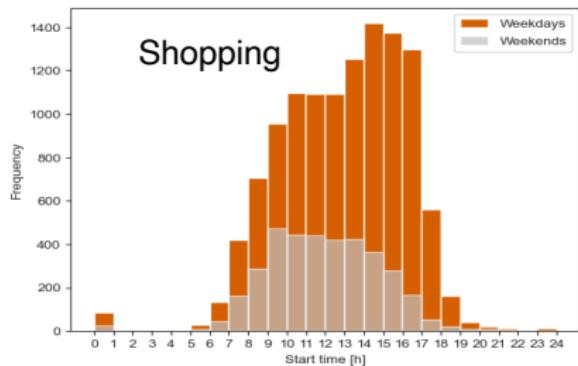
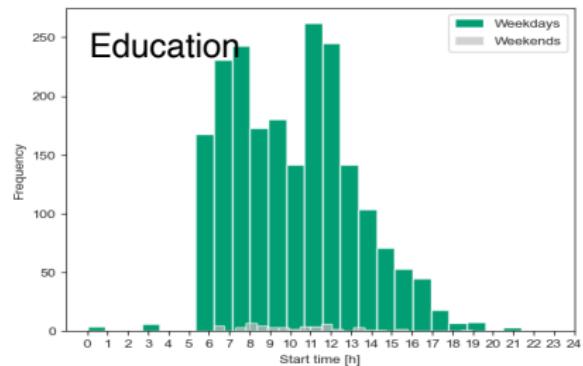
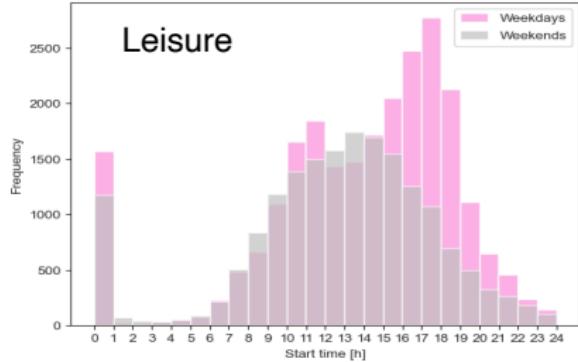
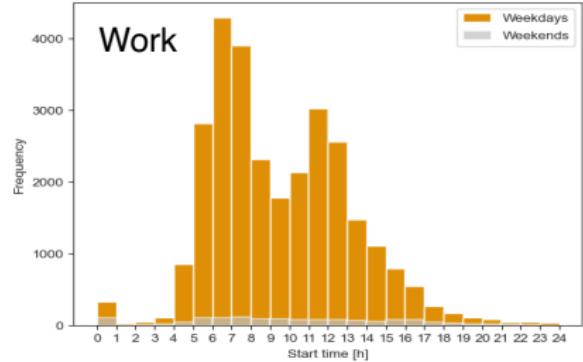
- Model 2 (unweighted): multiobjective function, $w_d = 1 \quad \forall d \in T$
- Model 3 (weighted): multiobjective, $w_{\text{weekdays}} = 0.8, w_{\text{weekend}} = 0.2.$

Data

- MOBIS longitudinal dataset (Molloy et al., 2022)
 - 8 weeks of GPS traces for 3680 respondents in Switzerland
- Random sample of 460 respondents:
 - Fit distributions of start times, durations, frequency over 8 weeks
 - Draws used as proxy for preferences.

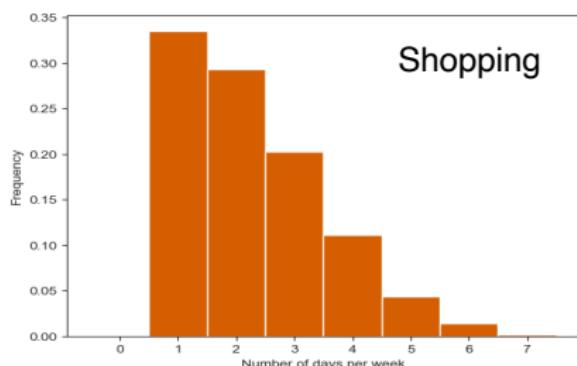
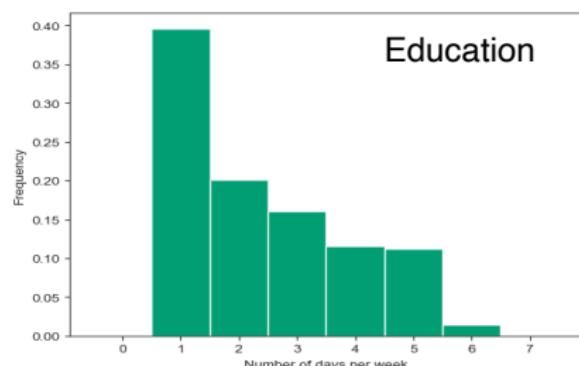
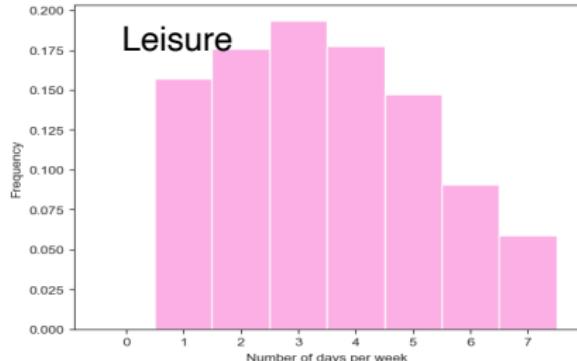
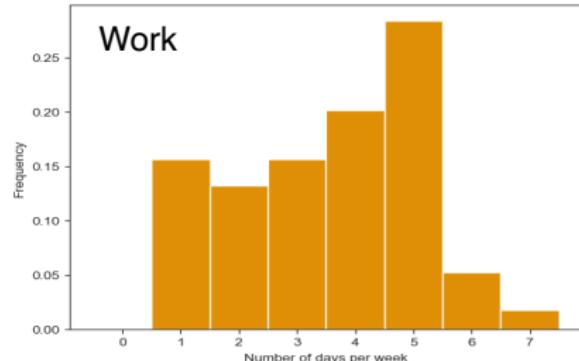
Preferences

Start time



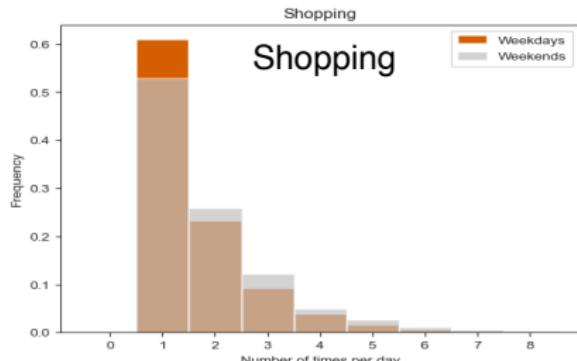
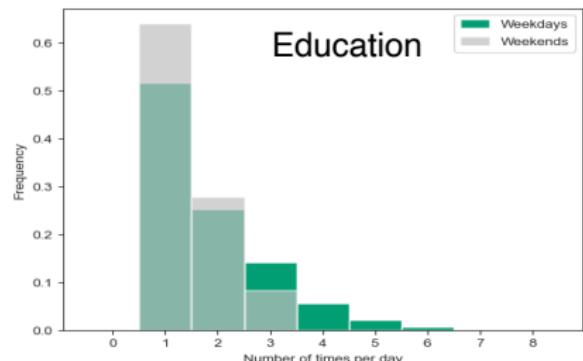
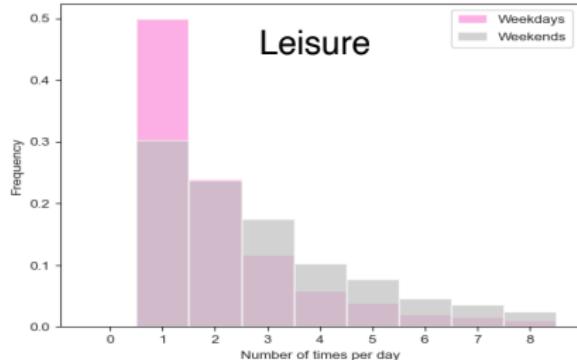
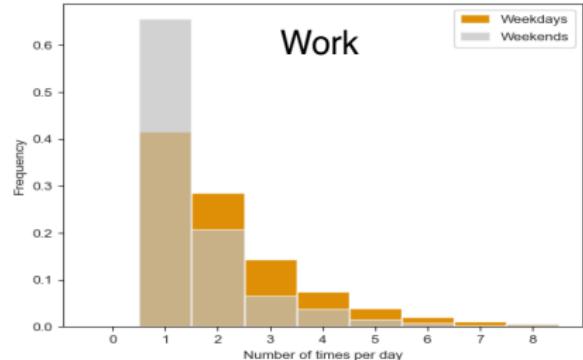
Preferences

Weekly frequency



Preferences

Daily frequency

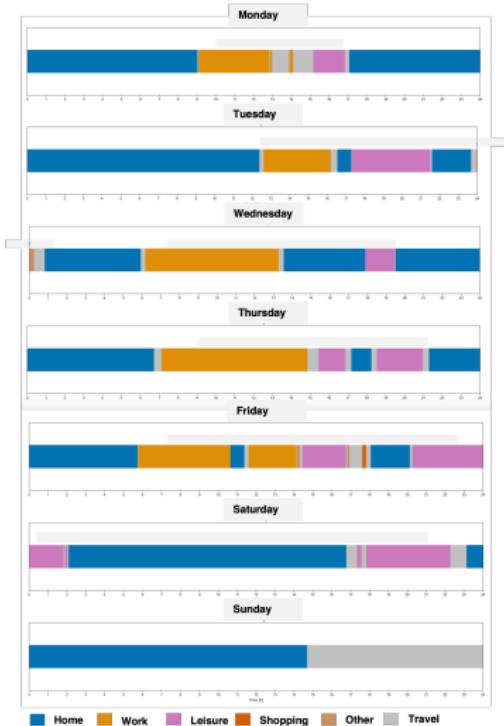


Parameters

- Initial assumption: same parameters as single day case
- Pougala et al. (2022):

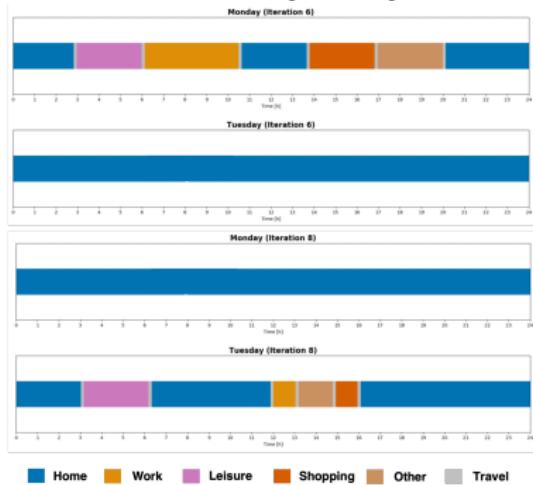
	Parameter	Param. estimate	Rob. std err	Rob. <i>t</i> -stat	Rob. <i>p</i> -value
1	$\gamma_{\text{education}}$	18.7	3.17	5.89	3.79e-09
2	$\theta_{\text{early education}}$	-1.35	0.449	-3.01	0.00264
3	$\theta_{\text{late education}}$	-1.63	0.416	-3.91	9.05e-05
4	$\theta_{\text{long education}}$	-1.14	0.398	-2.86	0.00428
5	$\theta_{\text{short education}}$	-1.75	0.457	-3.84	0.000123
6	γ_{leisure}	8.74	1.94	4.50	6.79e-06
7	$\theta_{\text{early leisure}}$	-0.0996	0.119	-0.836	0.403*
8	$\theta_{\text{late leisure}}$	-0.239	0.115	-2.07	0.0385
9	γ_{shopping}	10.5	2.20	4.78	1.74e-06
10	$\theta_{\text{early shopping}}$	-1.01	0.287	-3.51	0.000443
11	$\theta_{\text{late shopping}}$	-0.858	0.237	-3.63	0.000284
12	γ_{work}	13.1	2.64	4.96	7.16e-07
13	$\theta_{\text{early work}}$	-0.619	0.217	-2.85	0.00438
14	$\theta_{\text{late work}}$	-0.338	0.168	-2.02	0.0438
15	$\theta_{\text{long work}}$	-1.22	0.348	-3.51	0.000441
16	$\theta_{\text{short work}}$	-0.932	0.213	-4.37	1.23e-05

Input schedule



First results

Weekdays only



(Weekend only: only schedules at home)

Fri-Sat



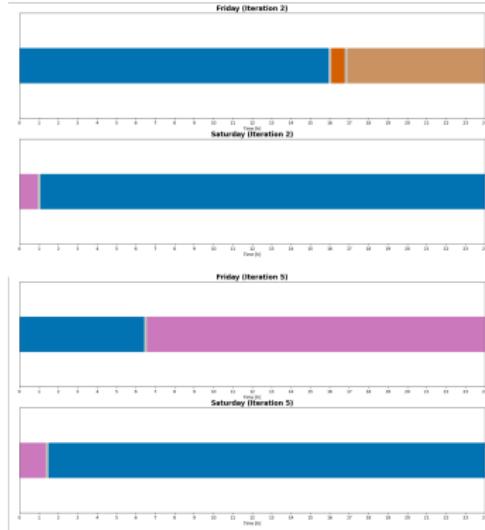
First results

Relaxing the **return home** constraint (Fri-Sat) ... not great

Unweighted utility function



Weighted utility function

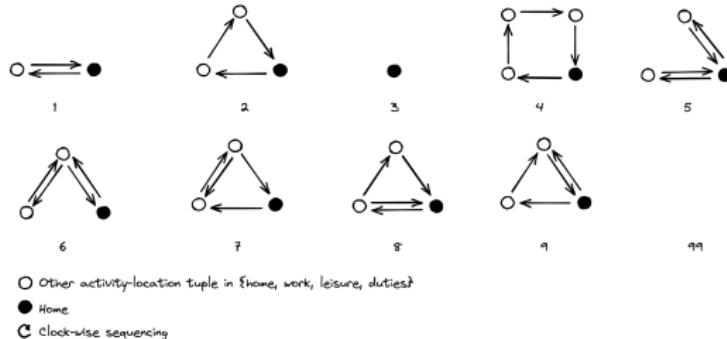


■ Home ■ Work ■ Leisure ■ Shopping ■ Other ■ Travel

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Further work

- Parameter estimation
- Model specification:
 - Momentum term (similarity measure)
 - Latent class model for schedule preferences and objective function weights
- Sensitivity analysis
 - e.g. Week of schedules for full-time workers vs. part time



Schultheiss (2021)

Thank you!

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