An optimisation framework for activity-based models

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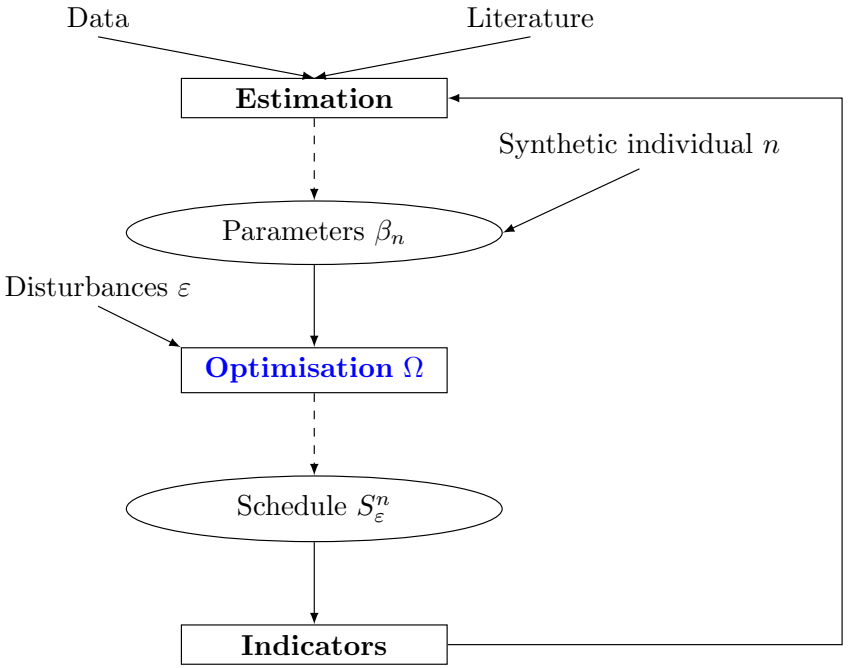
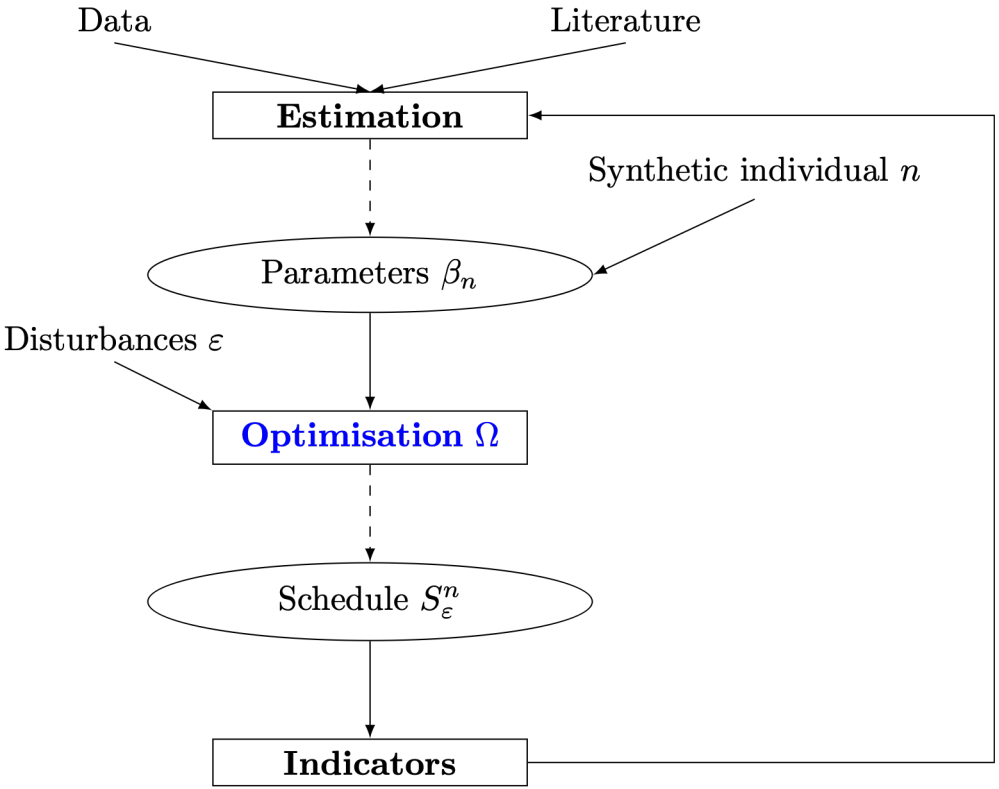
Framework

- Optimisation-based simulation framework for activity-based models
- Simultaneous estimation of all dimensions
  - Activity participation, scheduling, mode, location choice
- Explicitly capture **trade-offs**
- Combine econometric and rule-based approaches

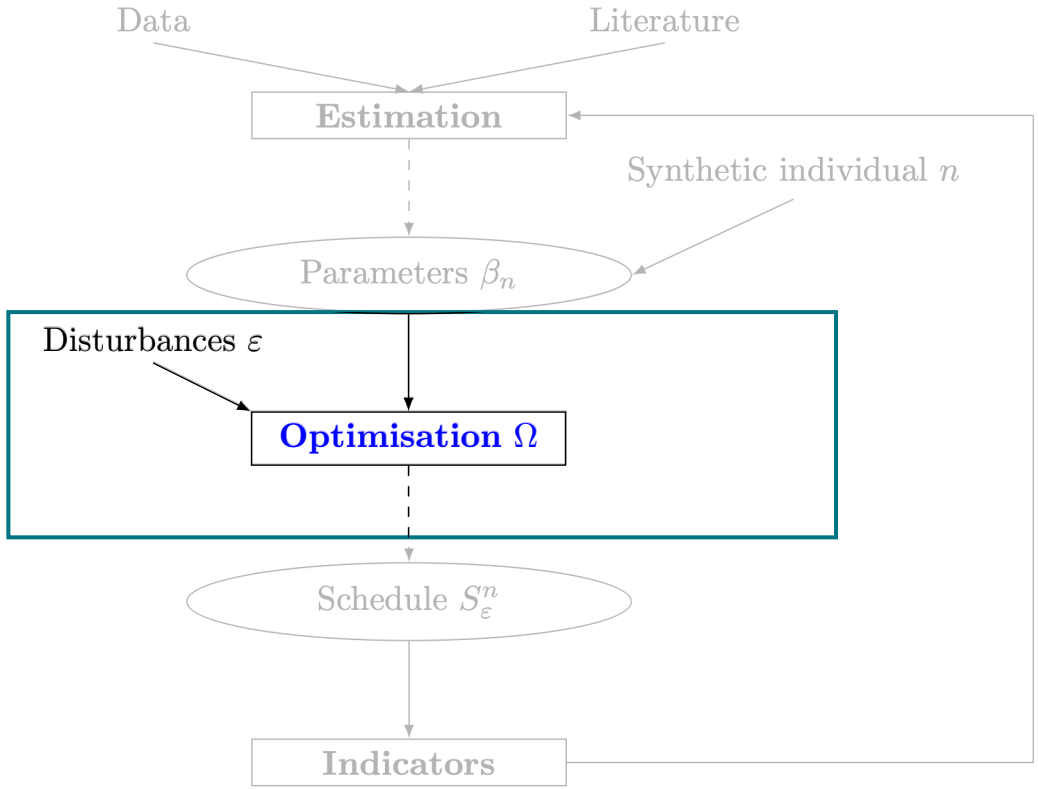


Framework

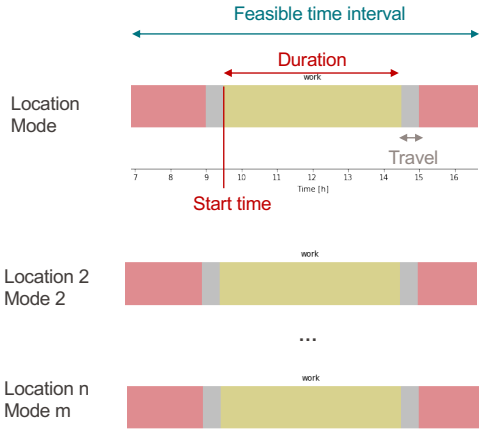

Data
Literature
Estimation
Synthetic individual n
Parameters β_n
Disturbances ε
Optimisation Ω
Schedule S_ε^n
Indicators

Framework

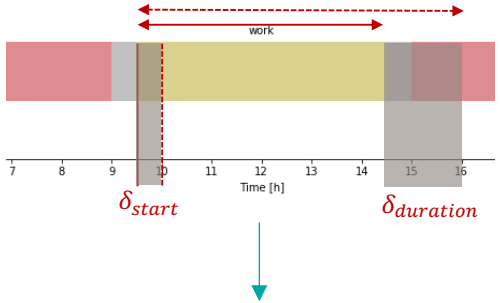
Simulation framework



Simulation



From an activity...



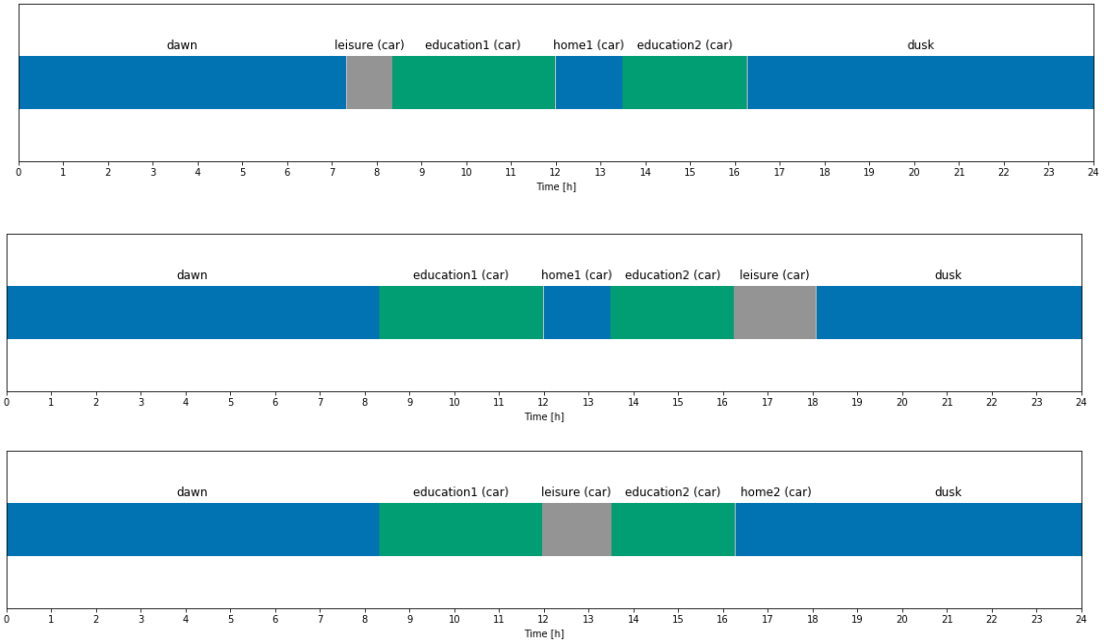
$$U_i(x_i, \tau_i, \delta_{xin}, \delta_{\tau in}, t_i, \omega_{in})$$

…to a utility function...

$$\Omega_n = \max \sum_i w_{in} U_{in}$$

… to a maximisation problem

Simulation



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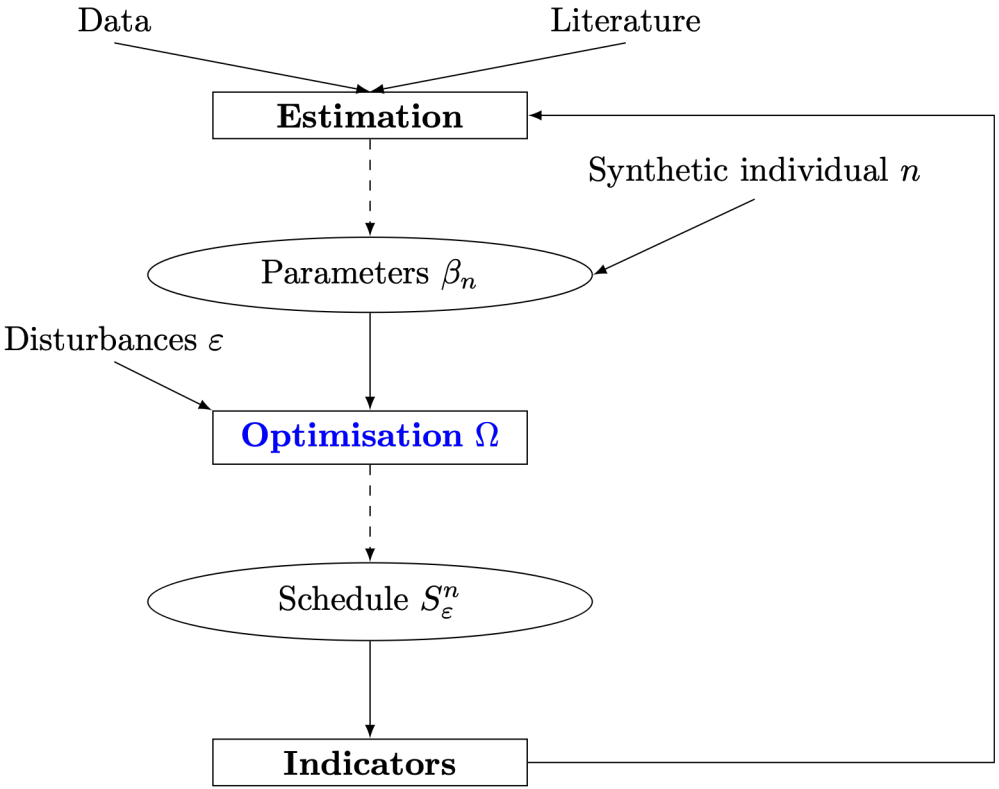
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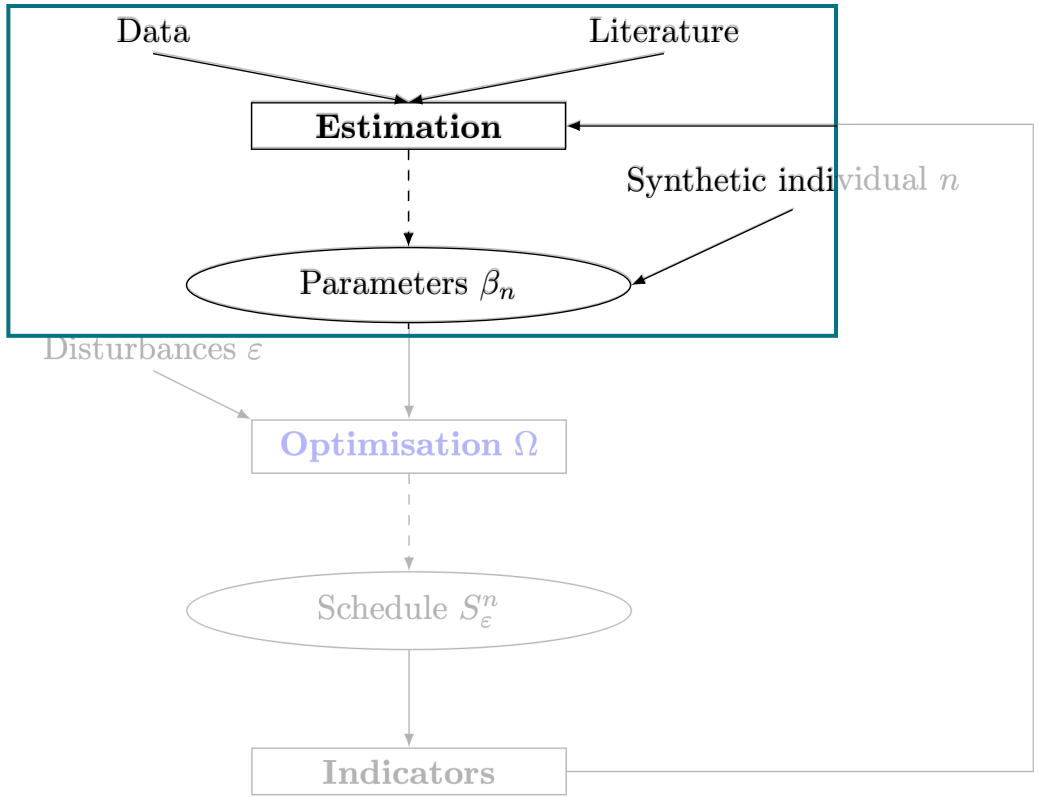
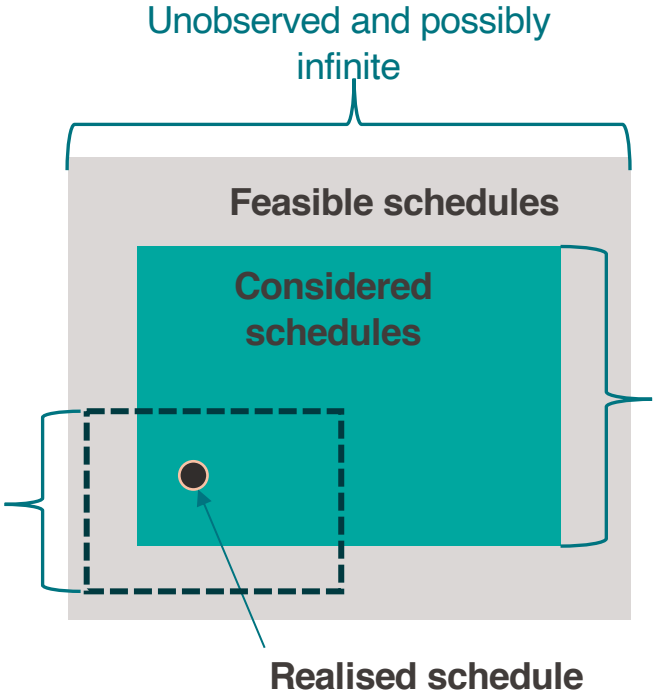
Parameter estimation



Estimation

Choice set generation



Estimation choice set: sample of feasible schedules generated for estimation purposes

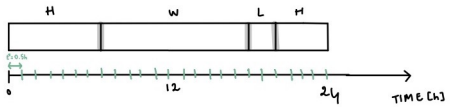
Actual choice set: Unobserved

Based on Shocker (1991)

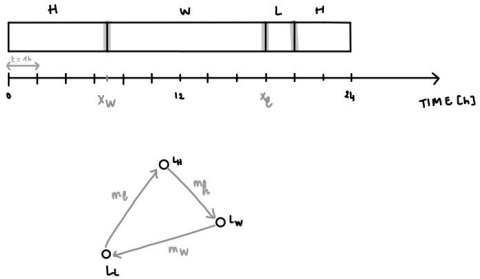
Estimation

- **Choice set generation**
  - Metropolis-Hastings sampling of feasible schedules

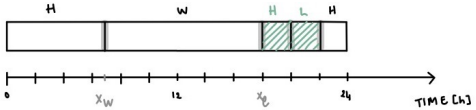
Block



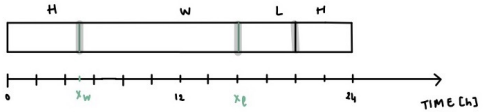
Initial state



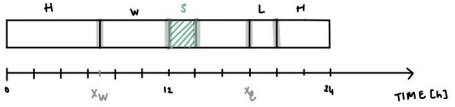
Swap



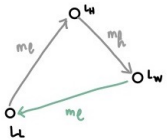
Inflate/Deflate



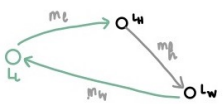
Assign



Mode



Location



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Estimation

- **Parameters**
- Utility of a schedule: $\mathrm{U_n} = \sum_a U_{an}$

  - For an individual n considering an activity a with a flexibility k:

$$U_{an} = U_{const} + U_{early} + U_{late} + U_{long} + U_{short} + U_{travel} + \varepsilon_{an}$$

Start time deviations:

$$U_{early} = \boldsymbol{\theta_{ek}} \max(0, \boldsymbol{x_a^*} - x_a)$$
$$U_{late} = \boldsymbol{\theta_{lk}} \max(0, x_a - \boldsymbol{x_a^*})$$

Duration deviations:

$$U_{short} = \boldsymbol{\theta_{dsk}} \max(0, \boldsymbol{\tau_a^*} - \tau_a)$$
$$U_{long} = \boldsymbol{\theta_{dlk}} \max(0, \tau_a - \boldsymbol{\tau_a^*})$$

Estimation

- **Mobility and Transport Microcensus 2015** (BFS & ARE, 2017)
- **Sample**
  - Students living in Lausanne (236 individuals)
- **Choice set size**
  - N = 10 alternatives

Model 0:

- Deviation parameters from literature

Model 1 (15 parameters):

- Activity-specific constants
- Aggregated penalties (flexible vs. Non flexible)

Model 2 (35 parameters):

- Activity-specific constants
- Activity specific penalties

Estimation

Model 1 ($\bar{\rho}^2 = 0.58$)

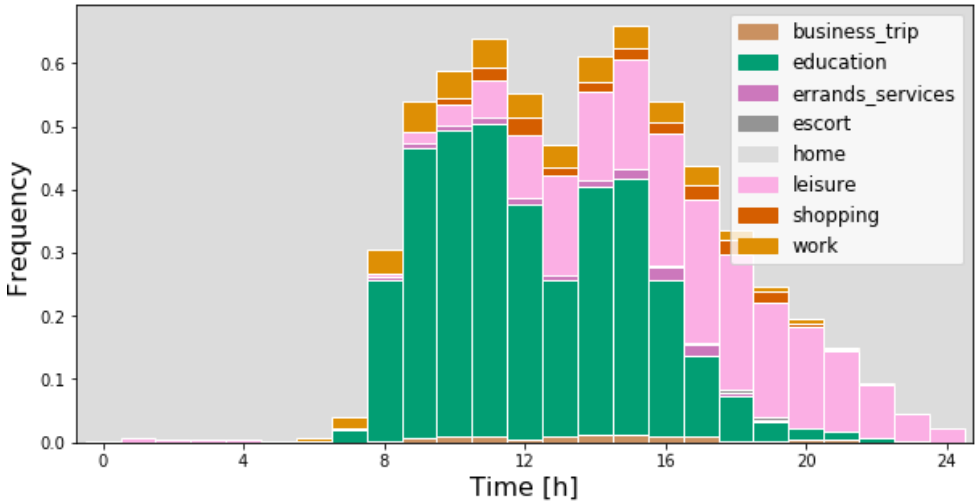
	Parameter	Param. estimate	Rob. std err	Rob. t-stat	Rob. p-value
1	F early	-0.418	0.147	-2.84	0.00451
2	F late	-1.12	0.209	-5.34	9.1e-08
3	F long	-0.11	0.0686	-1.6	0.109
4	F short	-0.132	0.242	-0.547	0.585
5	NF early	-1.35	0.342	-3.93	8.32e-05
6	NF late	-0.961	0.284	-3.39	6.97e-04
7	NF long	-0.112	0.111	-1.00	0.315
8	NF short	-0.908	0.529	-1.72	0.0859
9	ASC_Business Trip	7.22	2.21	3.26	0.00111
10	ASC_Education	12.3	2.13	5.78	7.57e-09
11	ASC_Errands	6.78	2.09	3.24	0.00119
12	ASC_Escort	6.84	1.42	4.81	1.51e-06
13	ASC_Leisure	10.5	2.11	4.96	7.19e-07
14	ASC_Shopping	7.71	1.72	4.5	6.95c-06
15	ASC_Work	8.15	1.84	4.42	1.00e-05

Model 2 - extract ($\bar{\rho}^2 = 0.632$)

	Parameter	Param. estimate	Rob. std err	Rob. t-stat	Rob. p-value
1	Education: ASC	18.0	6.05	2.98	0.00288
2	Education: early	-2.22	0.722	-3.07	0.00214
3	Education: late	-2.22	1.19	-1.87	0.0615
4	Education: long	-0.166	0.162	-1.02	0.306
5	Education: short	-2.12	1.29	-1.65	0.0991
6	Leisure: ASC	9.32	3.95	2.36	0.0184
7	Leisure: early	0.0456	0.247	0.184	0.854
8	Leisure: late	-0.975	0.357	-2.73	0.00639
9	Leisure: long	-0.104	0.0951	-1.09	0.276
10	Leisure: short	0.248	0.429	0.577	0.564
11	Work: ASC	9.10	3.97	2.29	0.0218
12	Work: early	-1.13	0.555	-2.03	0.042
13	Work: late	-0.395	0.342	-1.16	0.248
14	Work: long	-0.179	0.16	-1.12	0.263
15	Work: short	-1.92	0.922	-2.08	0.0377

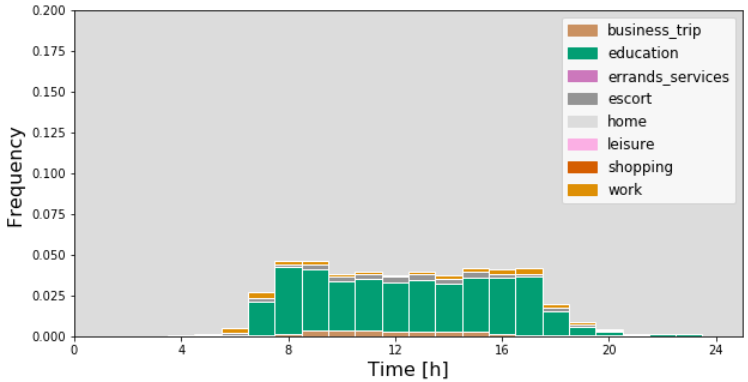
Estimation

- Observed time-of-day schedule distribution



Estimation

Model 0



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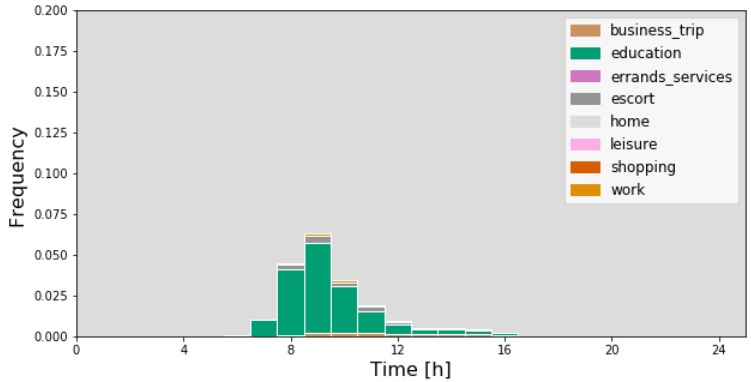
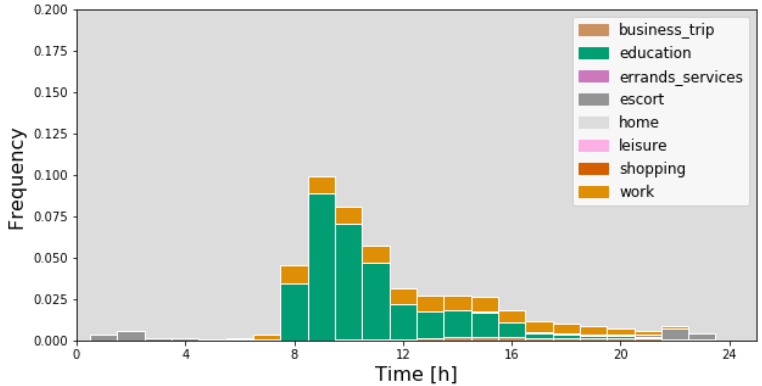
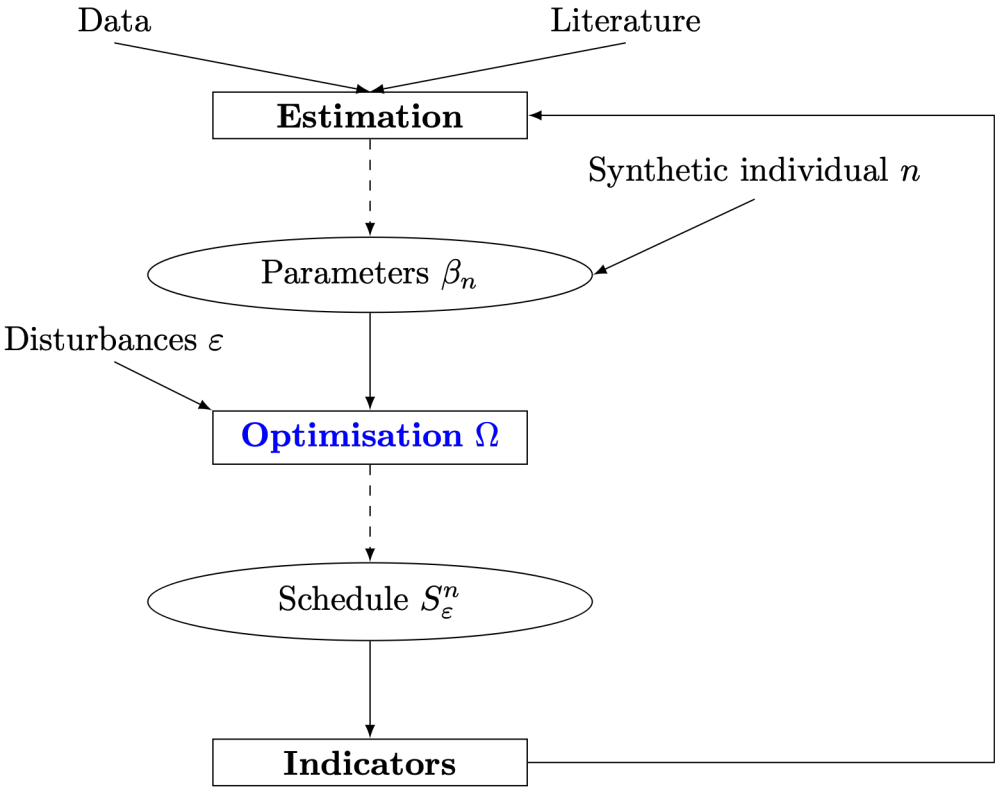


Model 2



Framework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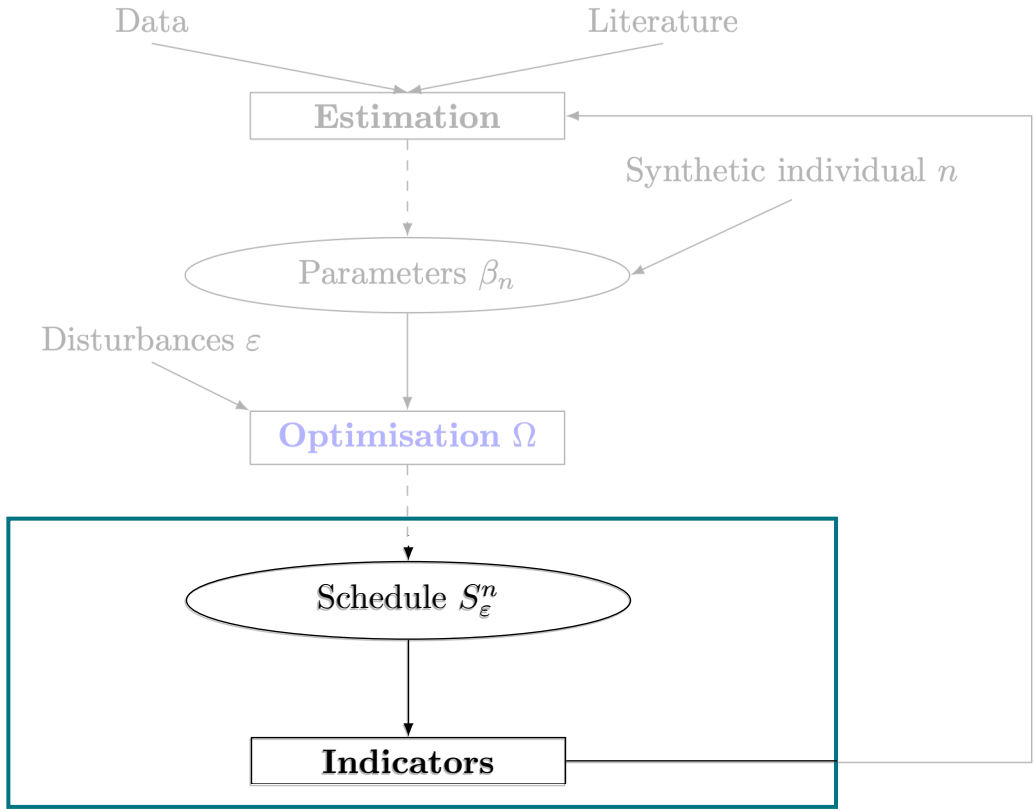

Application

Application

- **OPTIMS (OPT**imisation of **I**ndividual **M**obility **S**chedules**)**
  - Collaboration with Swiss Federal Railways (SBB)
  - Integration of optimisation model into SIMBA MOBi (SBB's forecasting framework)
  - https://github.com/optims-org/optims-sbb

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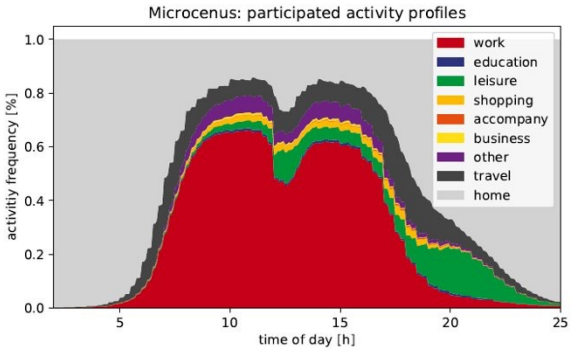
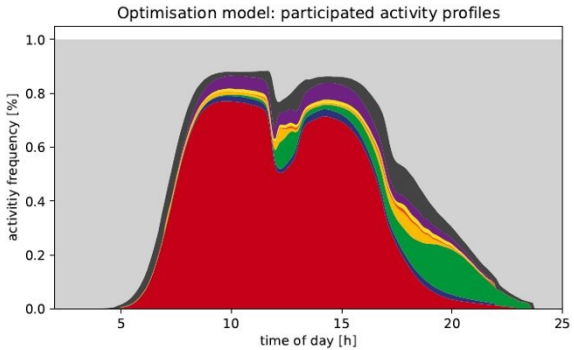
Innosuisse – Schweizerische Agentur für Innovationsförderung

SBB CFF FFS





Manser et al (2022)

Conclusion

Summary

- Optimisation framework to simulate activity schedules
  - Simultaneous estimation of all scheduling dimensions
  - Combining econometric and rule-based approaches
- Methodology to estimate the parameters
- Successful practical applications

Current challenges – future work:

- Validation
- Latent preferences
- Intra- and interpersonal interactions

Related publications

- Pougala J., Hillel T., Bierlaire M. (2022). ***Capturing trade-offs between daily scheduling choices.*** Journal of Choice Modelling 43 (100354)
- Manser P., Haering T., Hillel T., Pougala J., Krueger R., Bierlaire M. (to appear). ***Estimating flexibility preferences to resolve temporal scheduling conflicts in activity-based modelling.*** Transportation (accepted for publication on Aug 22, 2022)
- Pougala J., Hillel T., Bierlaire M. (2021) ***Choice set generation for activity-based models*****.** Proceedings of the 21st Swiss Transport Research Conference (STRC), 12-14 September, Ascona, Switzerland
- Pougala J., Hillel T., Bierlaire M. (2022) ***Parameter estimation for activity-based models*****.** Proceedings of the 22nd Swiss Transport Research Conference (STRC), 18-20 May, Ascona, Switzerland.

Thank you!

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