Activity-based models: recent developments in travel demand modeling

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Outline

Introduction

Why do people travel?

- Most of the time, not for the sake of it.
- Activities.
- Spread in space and time.

Activities

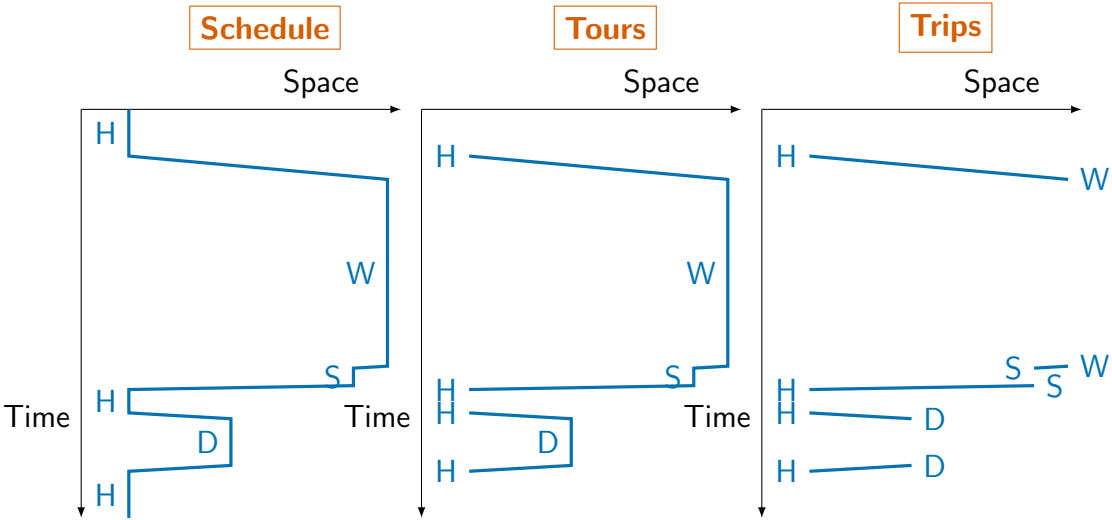
Primary

- home-based,
- work,
- education.

Secondary

- leisure,
- shopping,
- escort,
- business,
- etc.

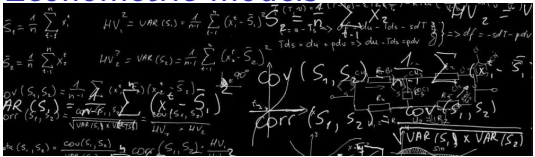
Travel demand models



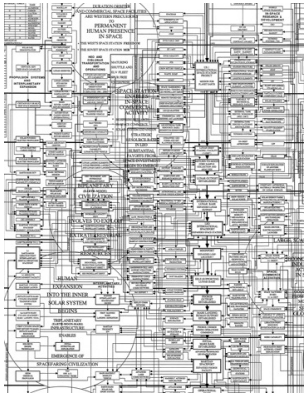
H: Home, W: Work, S: Shop, D: Dining out [Source: M. Ben-Akiva]

Activity-based models: literature

Econometric models



Rule-based models



Research question: can we combine the two?

	Econometric	Rule-based
Micro-economic theory	X	—
Parameter inference	X	—
Testing/validation	X	—
Joint decisions	—	X
Complex rules	—	X
Complex constraints	—	X

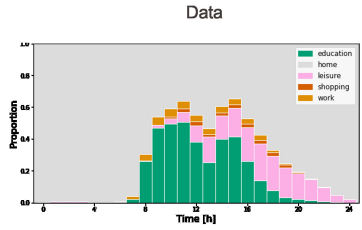
Outline

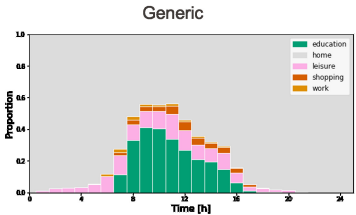
Integrated approach

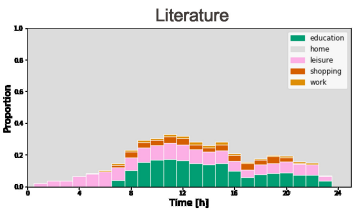
Mathematical optimization

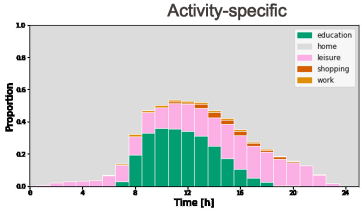
- Each individual is solving an optimization problem.
- Simultaneous decisions: activity participation, activity location, activity scheduling, travel mode, etc.
- Objective function: utility (to be maximized).
- Constraints: complex rules.

Visual validation





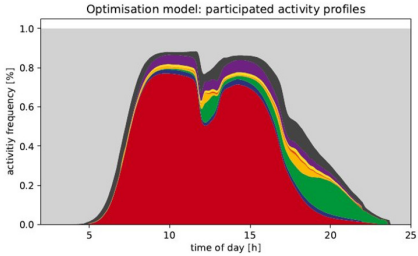


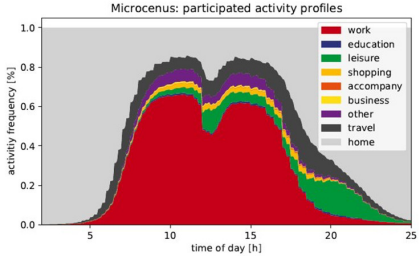


OPTIMs

OPTimization of **I**ndividual **M**obility **S**chedules,[Manser et al., 2022]

- Collaboration with Swiss Federal Railways.
- Integration of the optimization framework into their long-term travel demand forecasting tool (SIMBA MOBi).





Outline

Social groups

- Groups of individuals imply additional constraints.
- Coordination, joint activities.
- Group decision making
- Service to the group, maintenance.
- Resource constraints.
- Escorting.

Objective function: utility of the group

Group decision making

- Function of the utility of each member. But which function?
- Lack of consensus in the literature.
- Additive: the (weighted) sum of the utility of each member.
- Autocratic: the utility of the "strongest" member.
- Egalitarian: the utility of the "weakest" member.
- Important for our framework: must be easy to linearize.

Constraints

Coordinated activities

- a is an activity that must be performed by all members of the group.
- Dining out.
- Family gathering.
- Sport events.
- Activity participation of the group: w_{agr}.

$$\sum_{n \in g} w_{anr} = N_g w_{agr}.$$

Constraints

Distributed activities

- a is an activity that must be performed for the group.
- Maintenance.
- Grocery shopping.
- Meal preparation.
- Accounting of the sport club.

$$\sum_{n \in g} w_{anr} \geq 1.$$

Constraints

Resource constraints

- One car per household.
- One meeting room in a shared office space.
- Modeling approach: treat the resource as an individual.
- "The car is a member of the family".
- It is associated with "activities" and a schedule.
- We can then introduce "coordinated activities" constraints.

Constraints

Escorting a child to school

- Specific instance of a resource constraint.
- The person escorting becomes a resource.
- As individuals and resources are modeled in the same way, coordinated activities constraints can be applied.

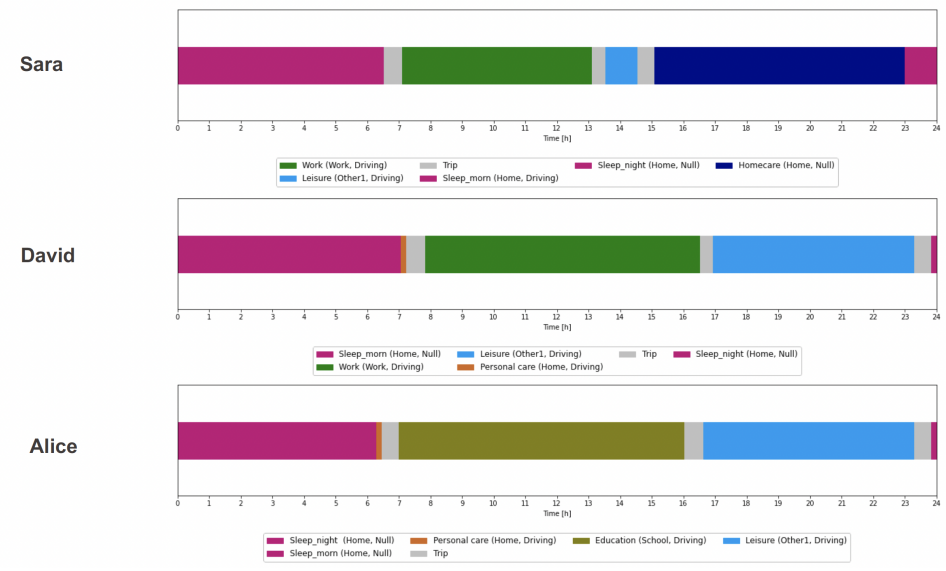
Mathematical optimization framework

Combining rule-based and econometric approaches

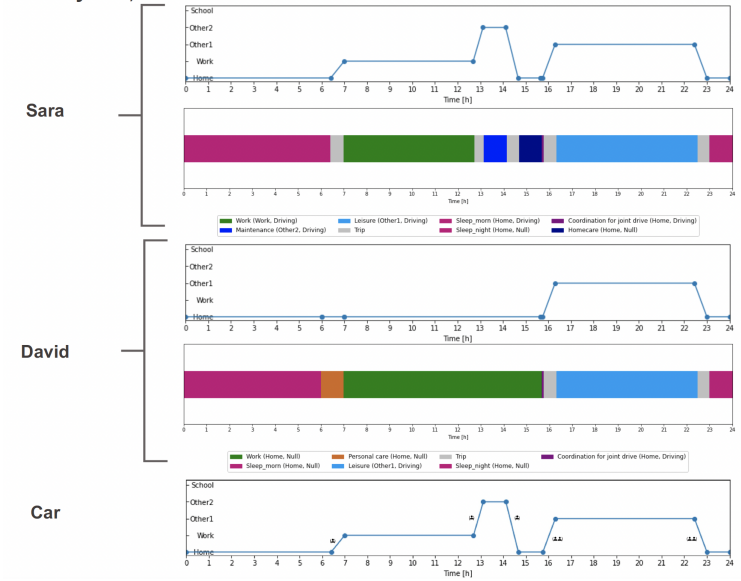
- Works well for the simulation of individuals decisions.
- Can easily be extended for social groups.
- Most "rules" can be translated into relatively simple mathematical constraints.
- Main issue: choice of the objective function.

Outline

Simulation: From isolated individuals...



Simulation: To family of 2; 2 adults with no children...

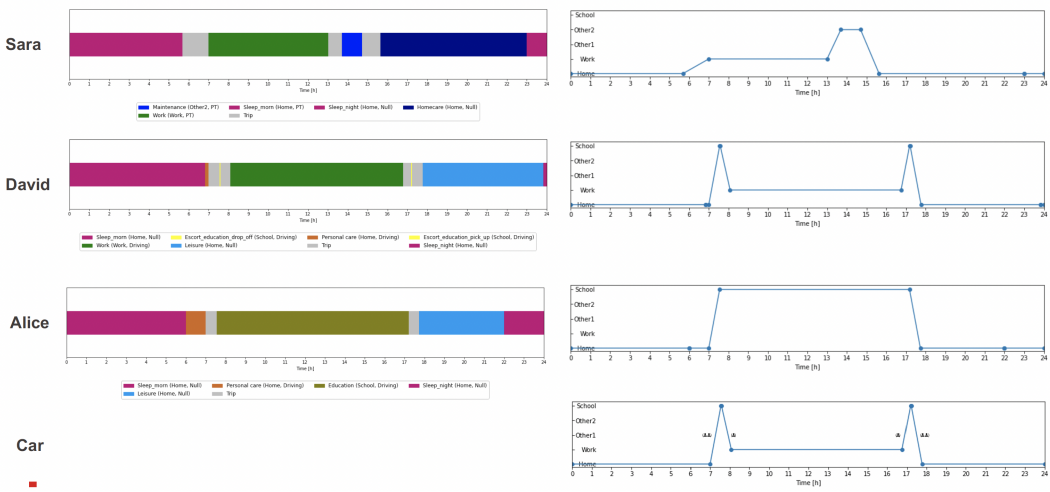


Simulation: Family of 2; 2 adults with no children...

Table: Car location sequence and occupancy in the example of a family of 2

Location	Start time (hh:mm)	End time (hh:mm)	Duration (hh:mm)	Person using	Parked_out indicator	Car occupancy
Home	00:00	6:24	6:24	-	0	0
On the road	6:24	7:00	0:36	1	0	1
Work	7:00	12:41	5:41	1	1	0
On the road	12:41	13:07	0:26	1	0	1
Other2	13:07	14:07	1:00	1	1	0
On the road	14:07	14:40	0:33	1	0	1
Home	14:40	15:45	1:05	-	0	0
On the road	15:45	16:18	0:33	1 & 2	0	2
Other1	16:18	22:27	6:08	1 & 2	1	0
On the road	22:27	23:00	0:33	1 & 2	0	2
Home	23:00	24:00	1:00	-	0	0

Simulation: To family of 3; 2 adults and 1 child...

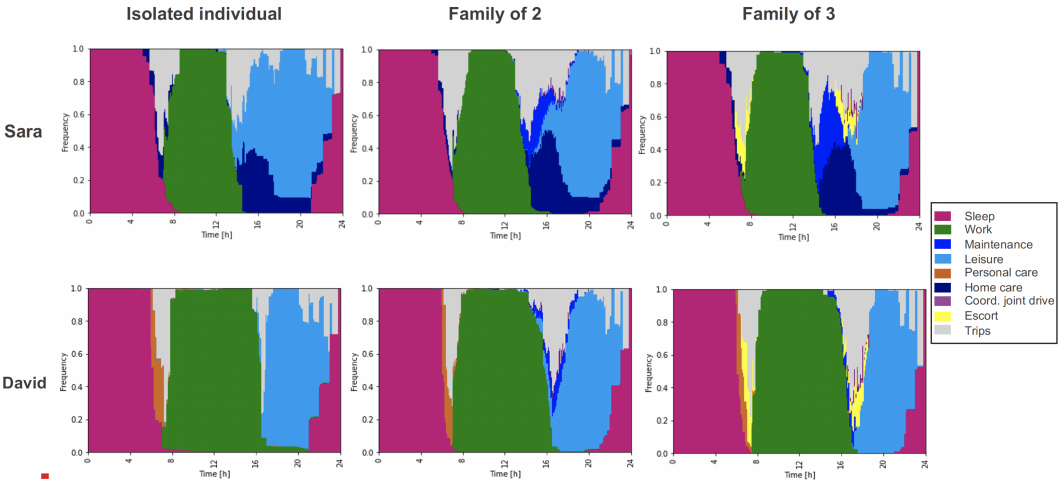


Simulation: Family of 3; 2 adults with 1 child...

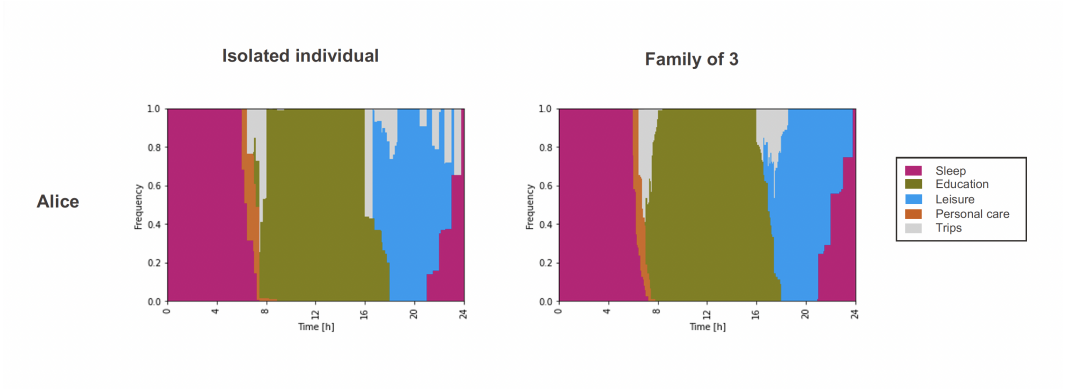
Table: Car location sequence and occupancy in the example of a family of 3

Location	Start time (hh:mm)	End time (hh:mm)	Duration (hh:mm)	Person using	Parked_out indicator	Car occupancy
Home	00:00	7:00	7:00	-	0	0
On the road	7:00	7:33	0:33	2 & 3	0	2
School	7:33	7:35	0:02	2	0	1
On the road	7:35	8:05	0:30	2	0	1
Work	8:05	16:45	8:40	2	1	0
On the road	16:45	17:11	0:26	2	0	1
School	17:11	17:13	0:02	2	1	1
On the road	17:13	17:46	0:33	2 & 3	0	2
Home	17:46	24:00	6:14	-	0	0

Distributions



Distributions



Conclusions

Achievements so far

- Formulation of the model.
- Procedure for the estimation of the parameters.
- Simulation of complex and valid activity schedules.
- Simulation of complex resources constraints.
- Simulation of household coordination.
- Application to real case studies.

Future research

Exploiting rich data sets

SBB's Continuous Mobility Panel (CMP).

Integration with transport simulation

MATSIM, SimMobility, etc.

Summary

- Motivation: design operational activity-based models.
- Combine the econometric and the rule-based approaches.
- Methodological contribution: use mathematical optimization and simulation.
- Simulation of activity schedule: [Pougala et al., 2022a].
- Application with the Swiss Railways: [Manser et al., 2021].
- Estimation of the parameters: [Pougala et al., 2022b].
- Household interactions: [Rezvany et al., 2023], [Rezvany et al., 2024].
- Main advantage of the framework: flexibility.

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