Travel demand

Activities, tours and trips

Michel Bierlaire

Introduction to transportation systems

EPFL

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

Combination of choices

- Choices of public authorities
- Choices of household/individuals
- Different time horizons

Choices of public authorities

Long-term

- urban planning and land use
- infrastructure: new metro line influences the real estate

Mid-term

- Regulations
- opening hours, events management, concerts, games

Short-term

- Crisis management
- storms (school closure), lockdown

Choices of households/individuals

Long-term

- Lifestyle: work, villa or apartment, number of children, etc.
- Mobility: GA, number of cars
- Regular activities (sport, theater, etc.)

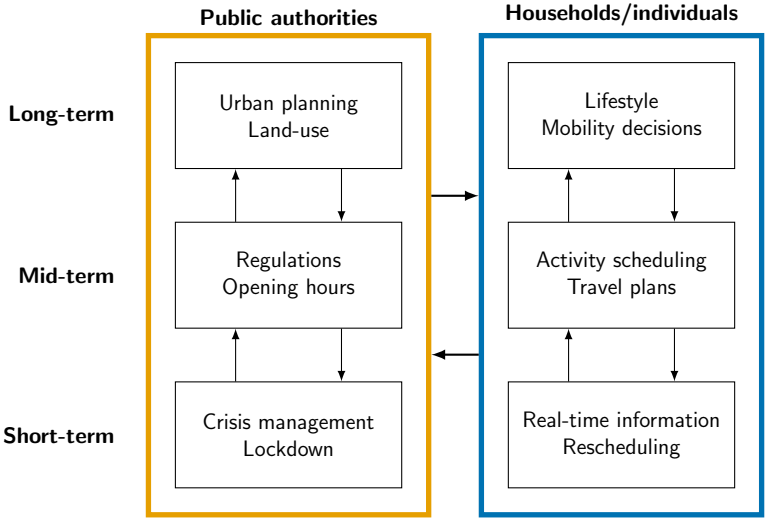
Mid-term

- Activity schedule
- Travel decisions

Short-term

- Activity reschedule
- Use of travel information

Choices and decisions



Modeling travel demand

Actors

- Each household.
- Each individual.

Decisions: example

Number of individuals		$7 \cdot 10^6$
Number of activities		10
Sequences		10!
Timing	10 per activity	100
Location	1000 per activity	10000
Mode	5 per activity	50
Route	10 per activity	100
Total		10^{23}

source: Moshe Ben-Akiva

Model complexity: examples

Elevator

- No need to know the entire schedule of people
- We need to know who presses the button

Metro

- Boarding and alighting
- Similar to the elevator

Park-and-ride

- Multiple modes
- Vehicle availability for the full tour

Impact of lockdown

- Need the details of the activities
- In particular, location

Model complexity

Granularity

- Time resolution
- Spatial discretization

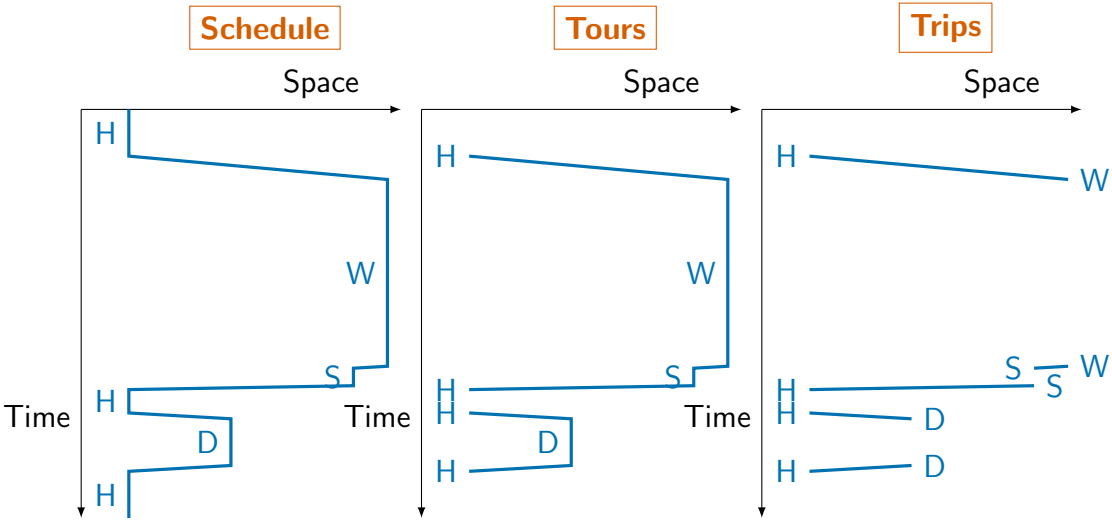
Level of aggregation

- Disaggregate: each individual
- Aggregate: flows

Travel patterns

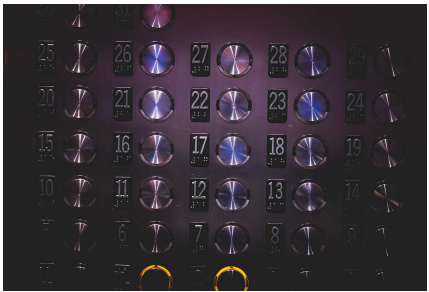
- Activity schedules
- Tours
- Trips

Travel demand models



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

Elevator example



Question

- How crowded are the elevators?

Granularity

- Time: morning peak hour
- Space: list of floors

Level of aggregation

- Flows
- All “travelers” are identical

Travel patterns

- Trips

Elevator example

Trips production

- Floors where people live
- Ground floor
- How many will leave during the peak hour?

Trips attraction

- Ground floor
- Floors where people work

Elevator example

Demographics

Floor	Residents	Workers
0	0	0
1	12	2
2	5	70
3	17	5
4	20	0

Elevator example

Production and attraction

Floor	Residents	Workers	Prod.	Attr.
0	0	0	51	26
1	12	2	10	0
2	5	70	3	51
3	17	5	7	2
4	20	0	8	0
			79	79

$0 + 51 + 2 + 0 \neq 51$ $10 + 3 + 7 + 8 \neq 26$

2 travelers do not use the ground floor Data: household structure (census, survey), counts (ground floor)

Who goes where?

Origin-destination table

	0	1	2	3	4	
0		0	50	1	0	51
1	10		0	0	0	10
2	3	0		0	0	3
3	6	0	1		0	7
4	7	0	0	1		8
	26	0	51	2	0	79

Origin-destination table

Table 1

	0	1	2	3	4	
0		0	50	1	0	51
1	10		0	0	0	10
2	3	0		0	0	3
3	6	0	1		0	7
4	7	0	0	1		8
	26	0	51	2	0	79

Table 2

	0	1	2	3	4	
0		0	49	2	0	51
1	9		1	0	0	10
2	3	0		0	0	3
3	7	0	0		0	7
4	7	0	1	0		8
	26	0	51	2	0	79

Not unique

Origin-destination table

Problem: under-determination

- M locations
- $M^2 - M$ unknowns, $2M$ equations
- M=5: 20 unknowns, 10 equations
- M=40: 1560 unknowns, 80 equations
- Infinite number of tables

Possible solutions

- Theory: more assumptions.
- Data: more observations.

Origin-destination table

Problem: incompatibility

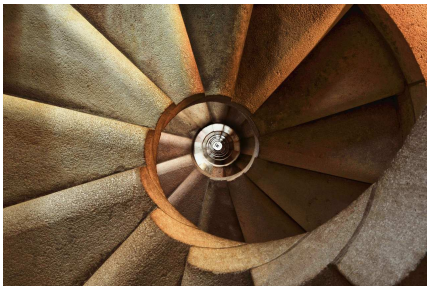
If sum of columns $\neq$ sum of row.

t_{11}	t_{12}	8
t_{21}	t_{22}	3
1	9	

Solution

- Use random variables

Mode choice



Choice

- Not everybody takes the elevator
- Some take the stairs

Criteria

- Number of floors
- Crowded elevators

Mode choice

Table for stairs

	0	1	2	3	4	
0	0	0	20	0	0	20
1	7	0	0	0	0	7
2	1	0	0	0	0	1
3	0	0	0	0	0	0
4	0	0	0	0	0	0
	8	0	20	0	0	28

Table for elevators

	0	1	2	3	4	
0	0	0	30	1	0	31
1	3	0	0	0	0	3
2	2	0	0	0	0	2
3	6	0	1	0	0	7
4	7	0	0	1	0	8
	18	0	31	2	0	51

Elevator choice

Several elevators

- People may prefer not to take the first one.
- Or the elevator may be full.
- The choice of elevator has an impact on the crowdedness.
- The crowdedness has an impact on the choice of elevator.

Public transportation Lausanne

Similar process

- Floors $\Longrightarrow$ Bus stops/metro stations
- Ground floor $\Longrightarrow$ Train stations
- Production and attraction $\Longrightarrow$ zones in the basin of attraction of the bus stops, counting
- OD table $\Longrightarrow$ similar issues: under-determination and incompatibility
- Mode choice $\Longrightarrow$ PT or not
- Elevator choice $\Longrightarrow$ itinerary choice

Trip-based model: the 4-step approach

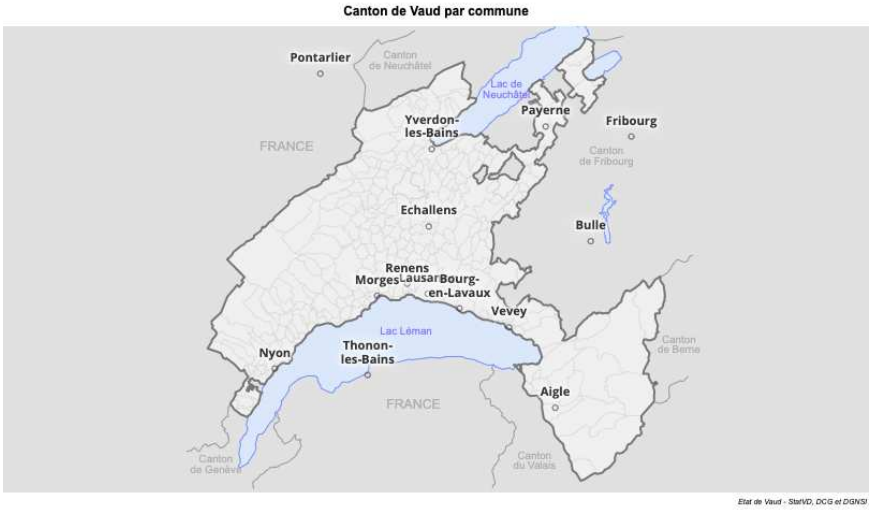
Time

- Time interval of interest.
- Focus on all trips starting and ending during this time interval
- Typical example: morning peak hour

Space

- Geographical area of interest.
- Partitioning into zones.
- Trips within a zone are ignored.
- Typical example: statistical zones, census units, etc.

Canton de Vaud



Source: vd.ch

Trip-based model: the 4-step approach

4-step approach

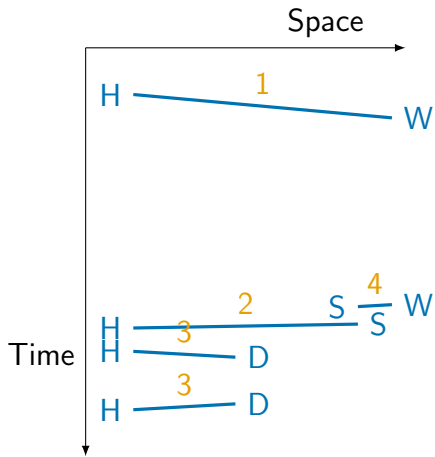
- Trip generation
- Trip distribution
- Modal split
- Assignment

Choices

- Trip purpose (activity), frequency
- Activity location, destination
- Transportation mode
- Route, itinerary

Trip purpose

1. Home-based work
2. Home-based shop
3. Home-based other
4. Non home-based



Trip generation

Linear regression

Production

Dependent variable

O_r: number of trips leaving zone r

Independent variables

- Individual characteristics
- Household characteristics
- Mobility tools
- Home location characteristics
- Accessibility

Attraction

Dependent variable

D_r: number of trips reaching zone r

Independent variables

- Land use per category (industrial, commercial, services)
- Employment
- Accessibility

Swiss model

Individual characteristics

- Level of education
- Sex
- Age
- Nationality
- Doing some home office
- Studying
- Function in the company
- Work percentage
- Language
- Business sector

Household characteristics

- Household structure
- Number of children 0-6, 6-15, 15+
- Couples without children with age below 30
- Couples without children with age between 30 and 49
- Income of the household

Swiss model

Mobility tools

- Car availability
- Number of cars in the household
- Public transport travel cards (GA, etc.)

Home location characteristics

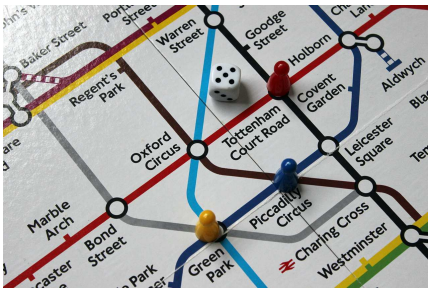
- Urban-rural typology of the place of living (urban, intermediate, rural)
- Region of the place of living

Accessibility

- Public transport connection quality of the place of living
- Home-work crow-fly distance

[?]

Trip-based model: the 4-step approach



4-step approach

- ✓ Trip generation
- Trip distribution
- Modal split
- Assignment

Before we proceed...

Transportation networks

Summary

Travel demand = derived demand

- Main needs: perform activities.

Choices

- Public authorities.
- Household/individuals.
- Different time horizons.

Model complexity

- Must be consistent with the needs.
- Too simple: useless.
- Too complex: intractable