Bevorzugter Zitierstil für diesen Vortrag

Axhausen, K.W. (2005) Modelling travel behaviour with OR tools: From microsimulation to fixed point problems, Vortrag für „Optimisation and Applications“, Institut für Operations Research, ETH Zürich, November 2005.

Modelling travel behaviour with OR tools: From microsimulation to fixed point problems

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November 2005

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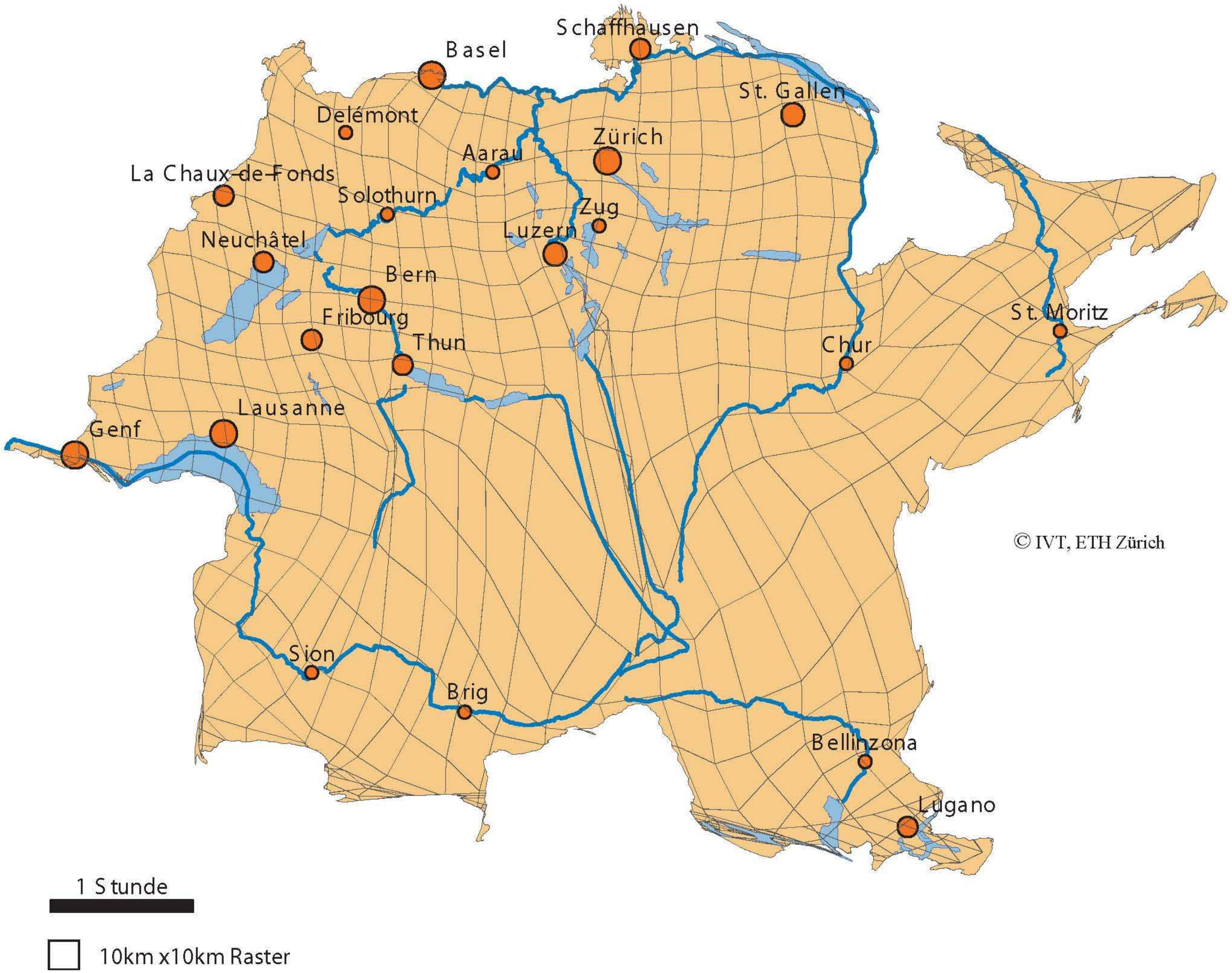
Should we expand the transport system further ?

“Road” - Switzerland (1950)

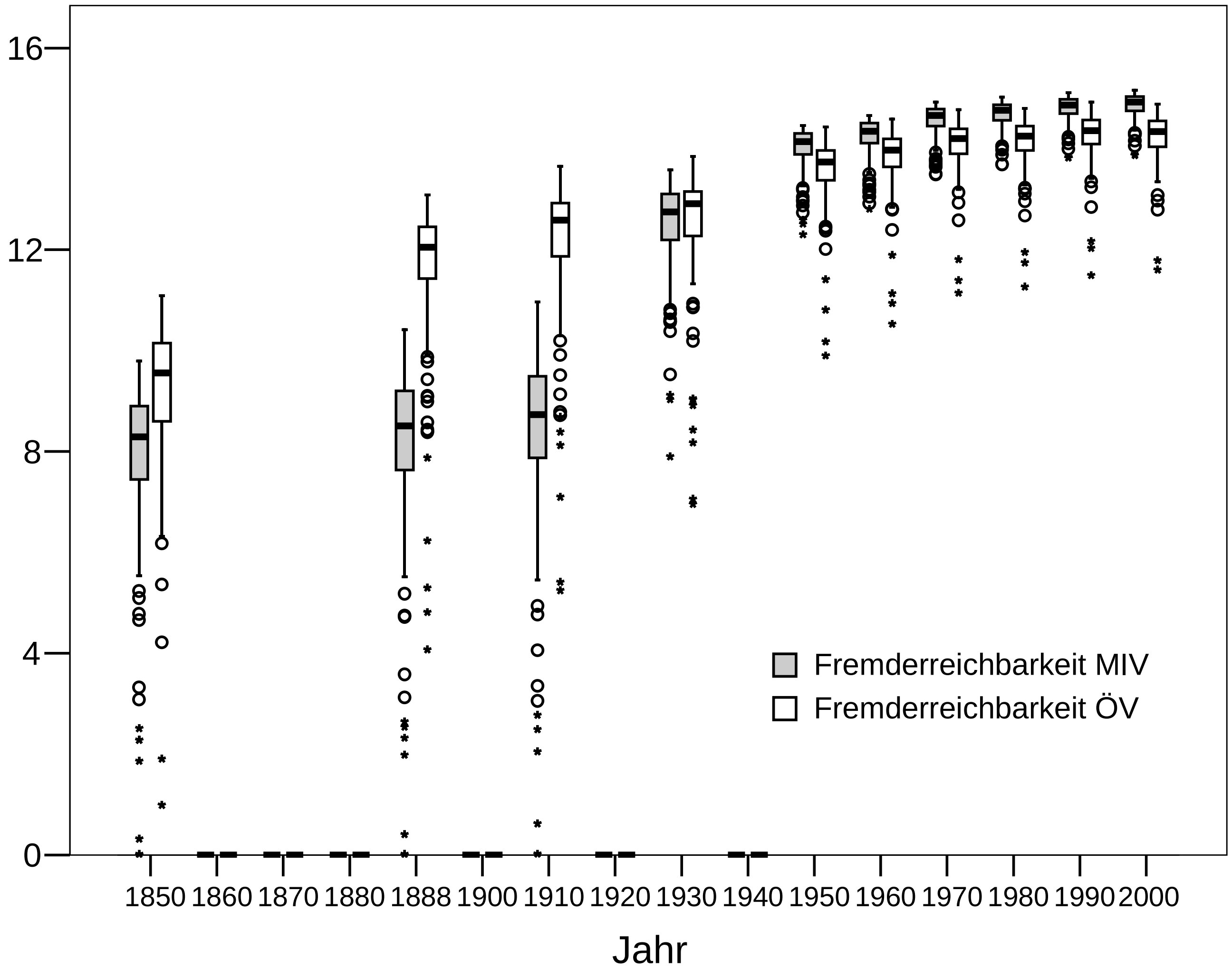


Scherer, 2004

“Road” - Switzerland (2000)

Scherer, 2004

Accessibility of Swiss districts since 1850



Without own accessibility of the districts

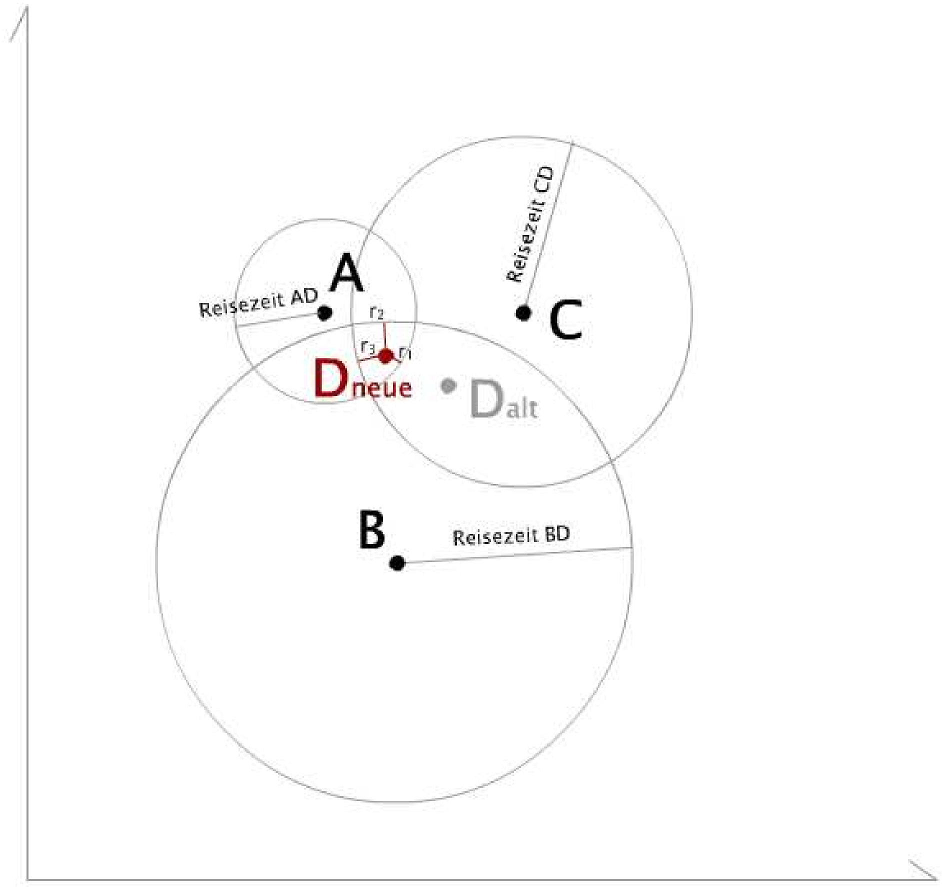
Scaling the travel time matrix

Scale of the problem:

- 3000*3000 travel times (along shortest time paths)

Solution:

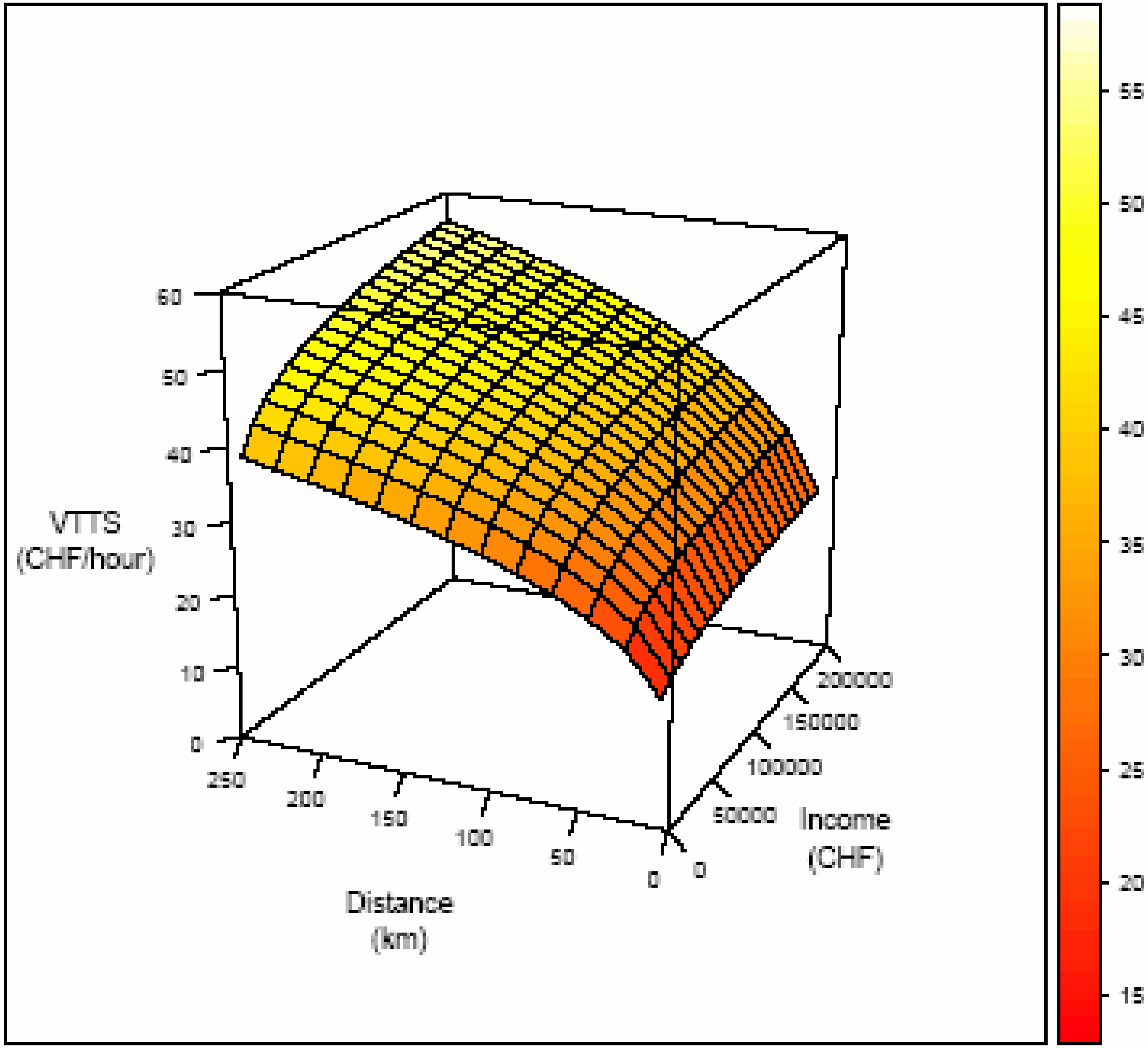
- Two stage scaling with subsamples
- Smoothing of remaining points



Carosio, Dolci and Scherer, 2005

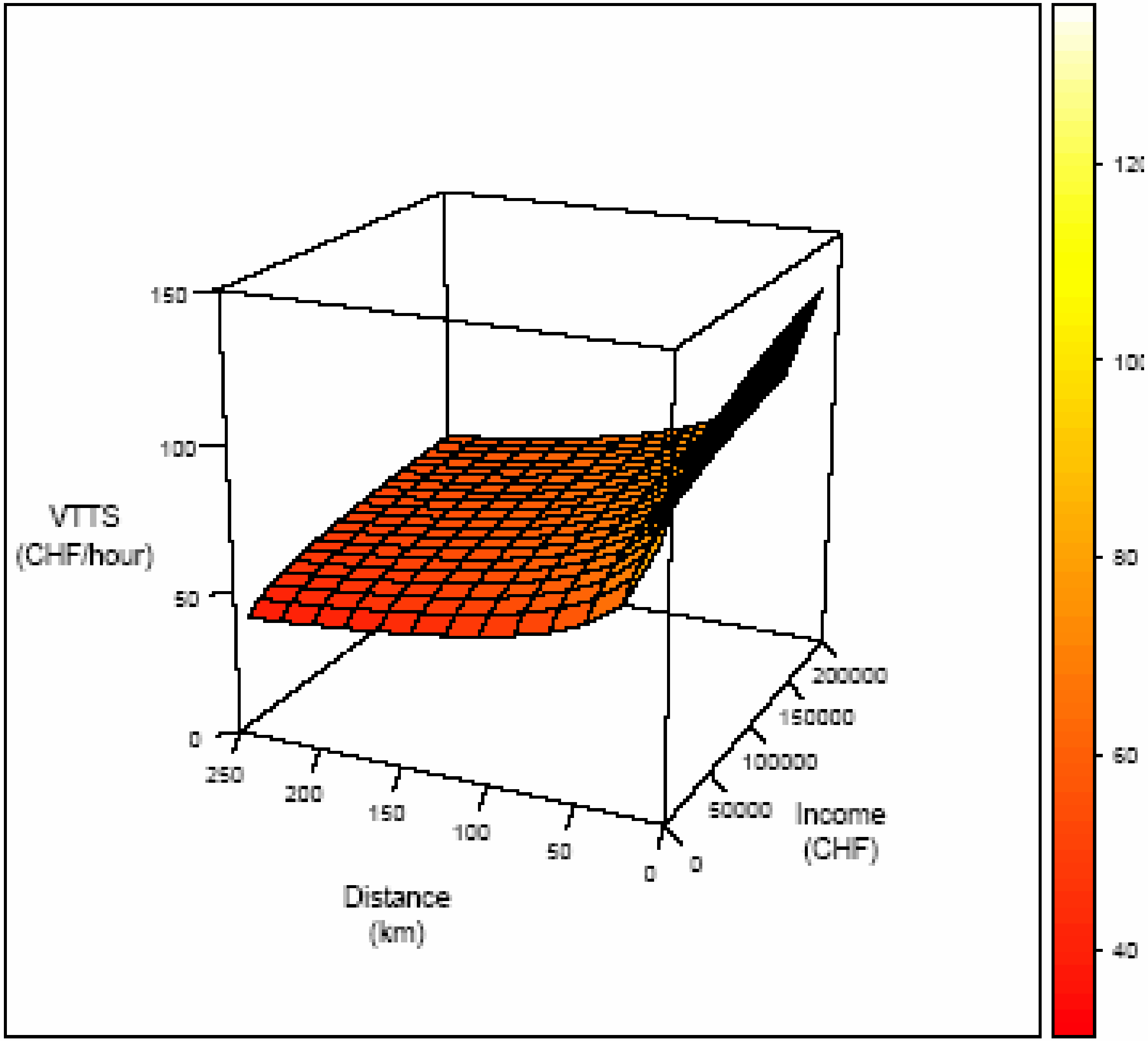
What do we want to pay for it ?

Willingness to pay for reduction of free-flow travel time



Axhausen, Hess, König, Bierlaire, Bates and Abay, 2006

Willingness to pay for reduction of congested travel time



Estimating the parameter set (1)

The standard MNL is:

$$P_{ni} = \frac{e^{V_{ni}}}{\sum_{j} e^{V_{nj}}}$$

But here:

$$V_{ni} = \mathrm{K}\ \beta_c \left(\frac{I_n}{\bar{I}} \right)^{\varepsilon_I} \left(\frac{D_n}{\bar{D}} \right)^{\varepsilon_D} c_{ni}\, \mathrm{K}$$

Estimating the parameter set (2)

Allowing for taste variation we obtain:

$$P_{ni} = \int L_{ni}(\beta)\phi(\beta \mid \theta)d\beta$$

Which requires:

$$\max_{\theta} SLL^{R}(\theta) = \max_{\theta} \frac{1}{N}\sum_{n=1}^{N} \ln SP_{ni_n}^{R}(\theta)$$

$$SP_{ni_n}^{R} = \frac{1}{R}\sum_{r=1}^{R} L_{ni_n}(\beta_r, \theta)$$

Where do we travel today ?

Dimensions of travel behaviour

Out-of-home time (0; A > 0)

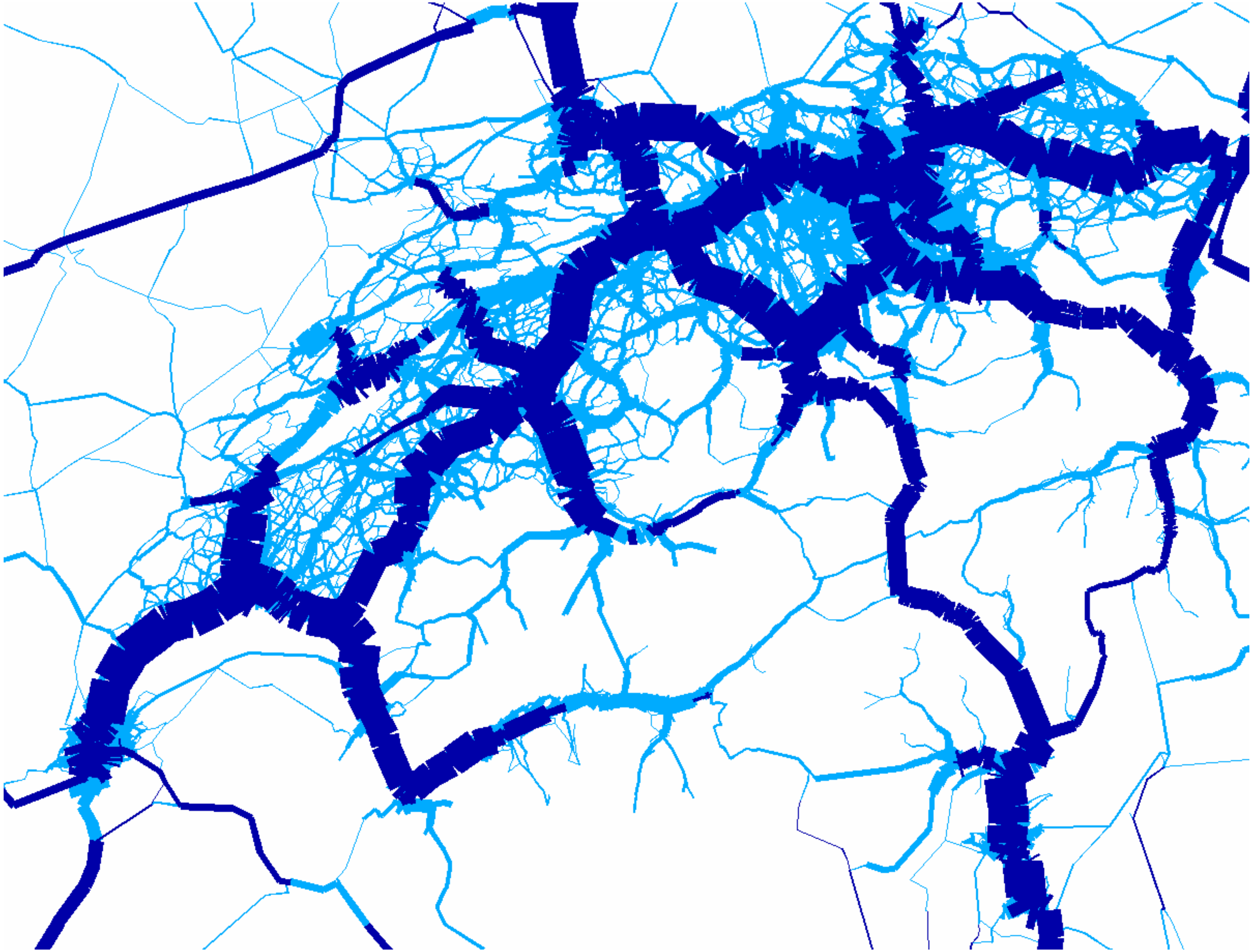
Allocation of out-of-home time to travel and activities
Sequence and time of the activities (and therefore travel)
(Persons travelling along and sharing in the activities)

Destination

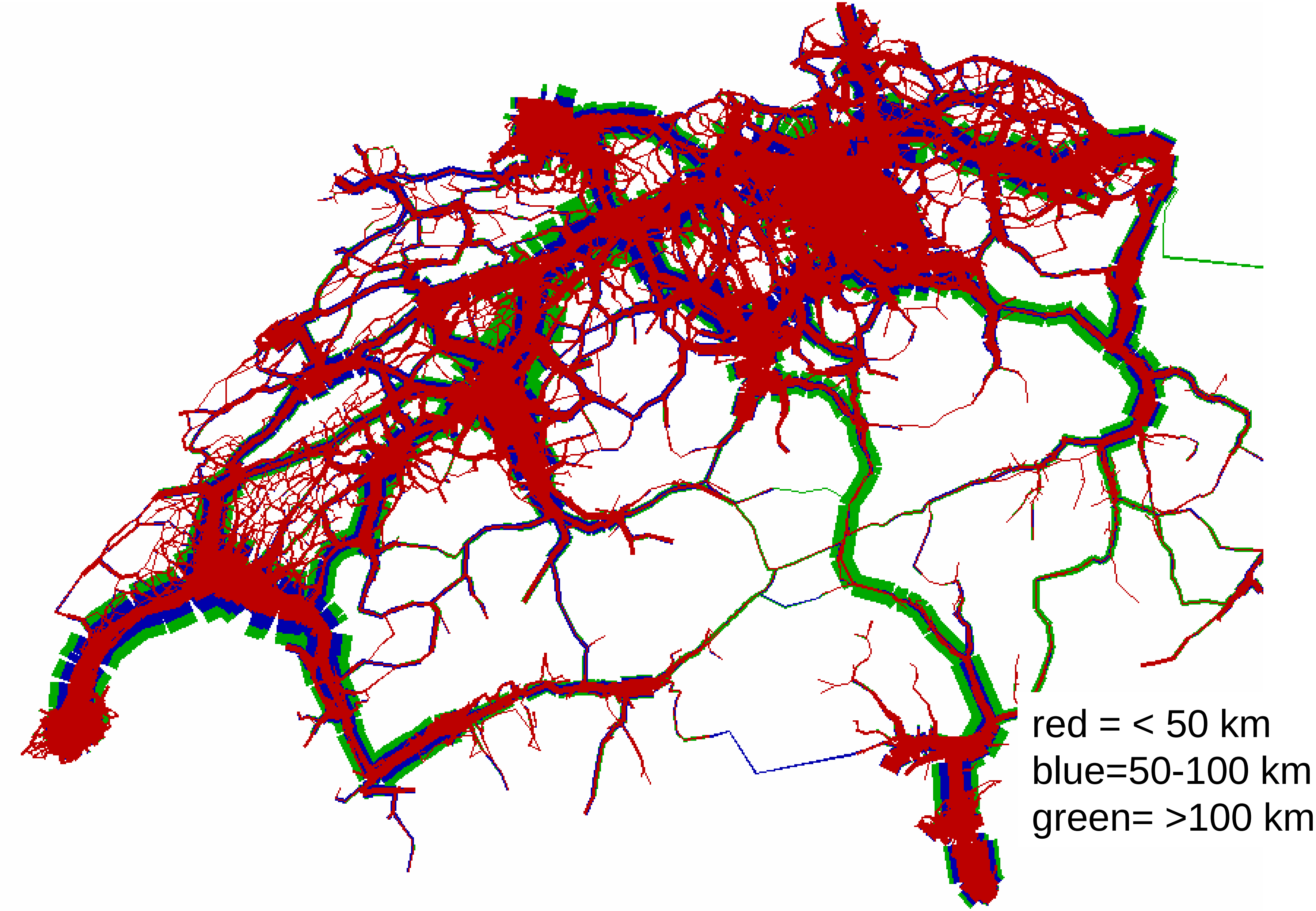
Mode
Route (Connection)

(Expenditure for travel and activities)

User equilibrium [by road type]



User equilibrium [by distance class]



UE differences between 3% and 0.01% relative deviation

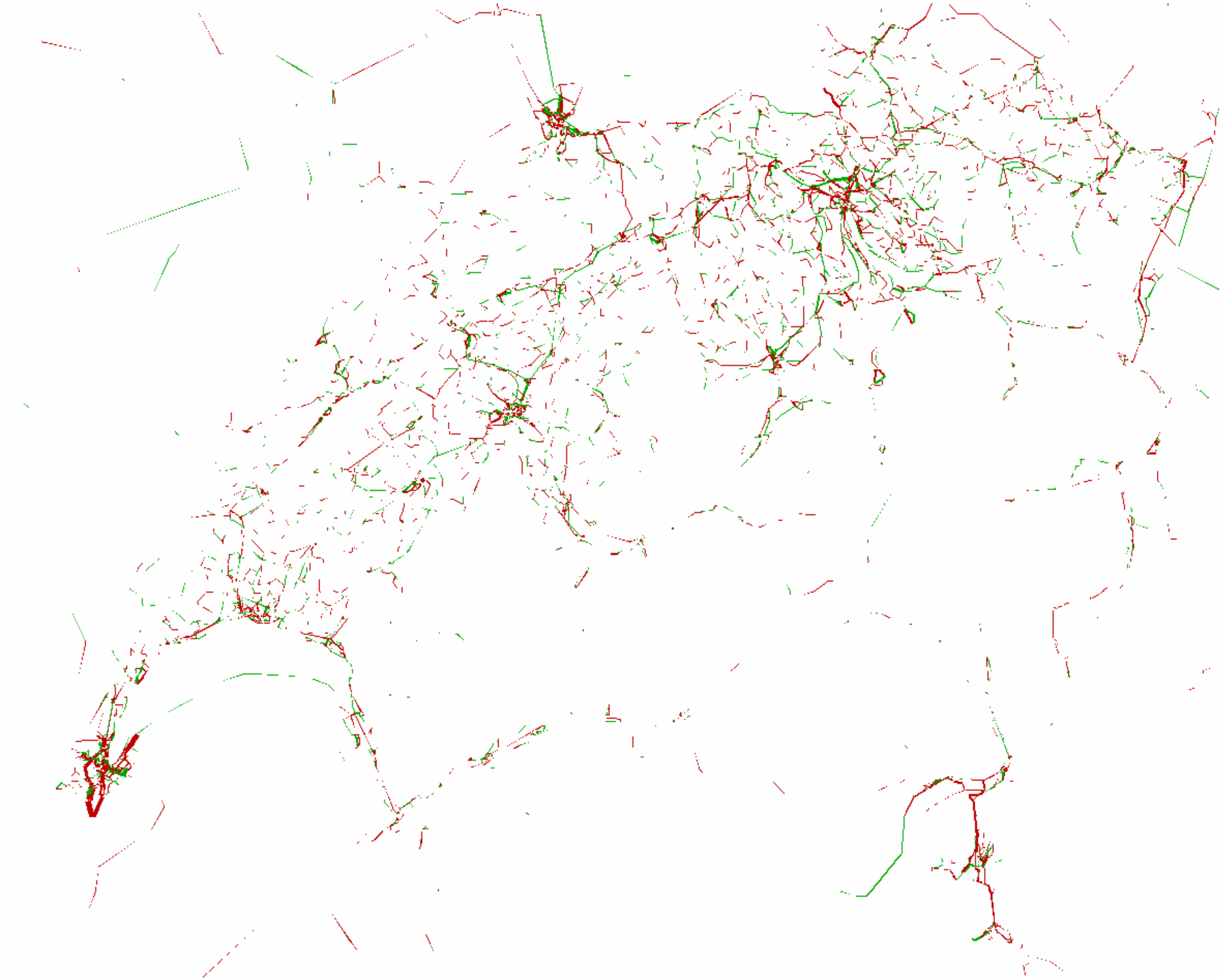
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
bis 2500 Fzg	28304	2415	760	403	268	154	99	74	121	486
bis 5000 Fzg	4268	925	404	268	211	105	67	49	29	316
bis 7500 Fzg	1765	514	217	103	79	35	29	19	19	108
bis 10000 Fzg	895	211	82	50	21	16	6	10	5	47
bis 12500 Fzg	518	142	22	7	3					6
bis 15000 Fzg	256	29	4	3	1					
bis 17500 Fzg	200			1						
bis 20000 Fzg	136	16	2							
bis 22500 Fzg	134	4	2		4					
bis 25000 Fzg	74	4								
bis 27500 Fzg	106	9								
bis 30000 Fzg	45									
über 30000 Fzg	143									

Computational costs of UE accuracy

Relative deviation in equilibrium	Computing time [High end PC]
3%	½ h
1%	2 h
0.1%	4 h
0.01%	8 h
0.001%	16 h

Schüssler, 2005

Difference between SUE and UE (3% relative deviation)



Schüssler, 2005

Complete fixed point system

The complete aggregate model system is:

$k'_{tsmgz} = k[q'_{tsmgz}(k'_{tsmgz}, B_{igz}), A_{tsmz}]$

k'	:	Estimated generalised costs
q	:	Estimated demand
A	:	Supply (slots, services, opportunities)
B	:	Population (natural and legal persons)

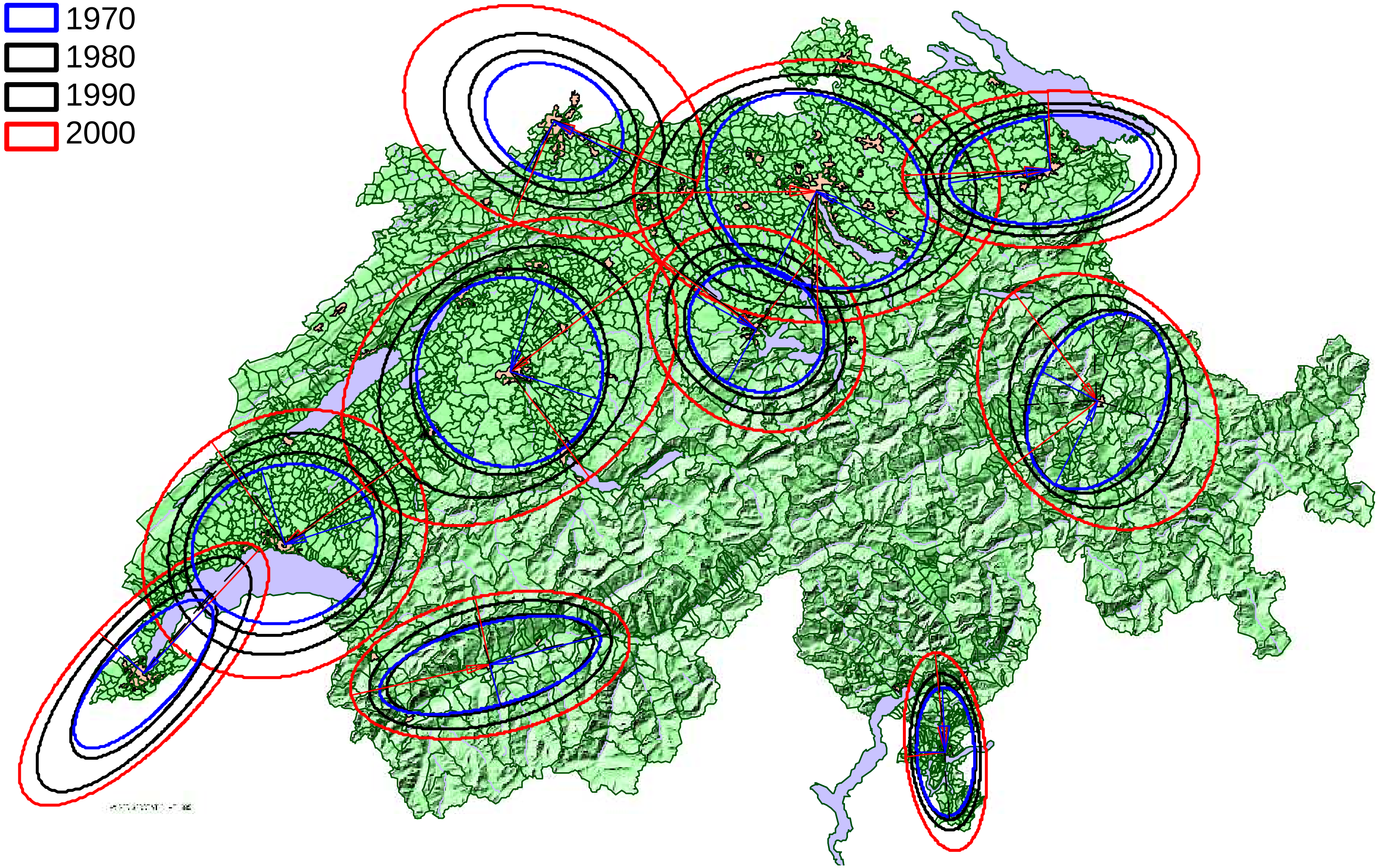
t	:	time of day t	i	:	Origin i
s	:	link s	j	:	Destination j
r	:	route r	g	:	Group g
m	:	mode m	z	:	Year
z					

Challenges

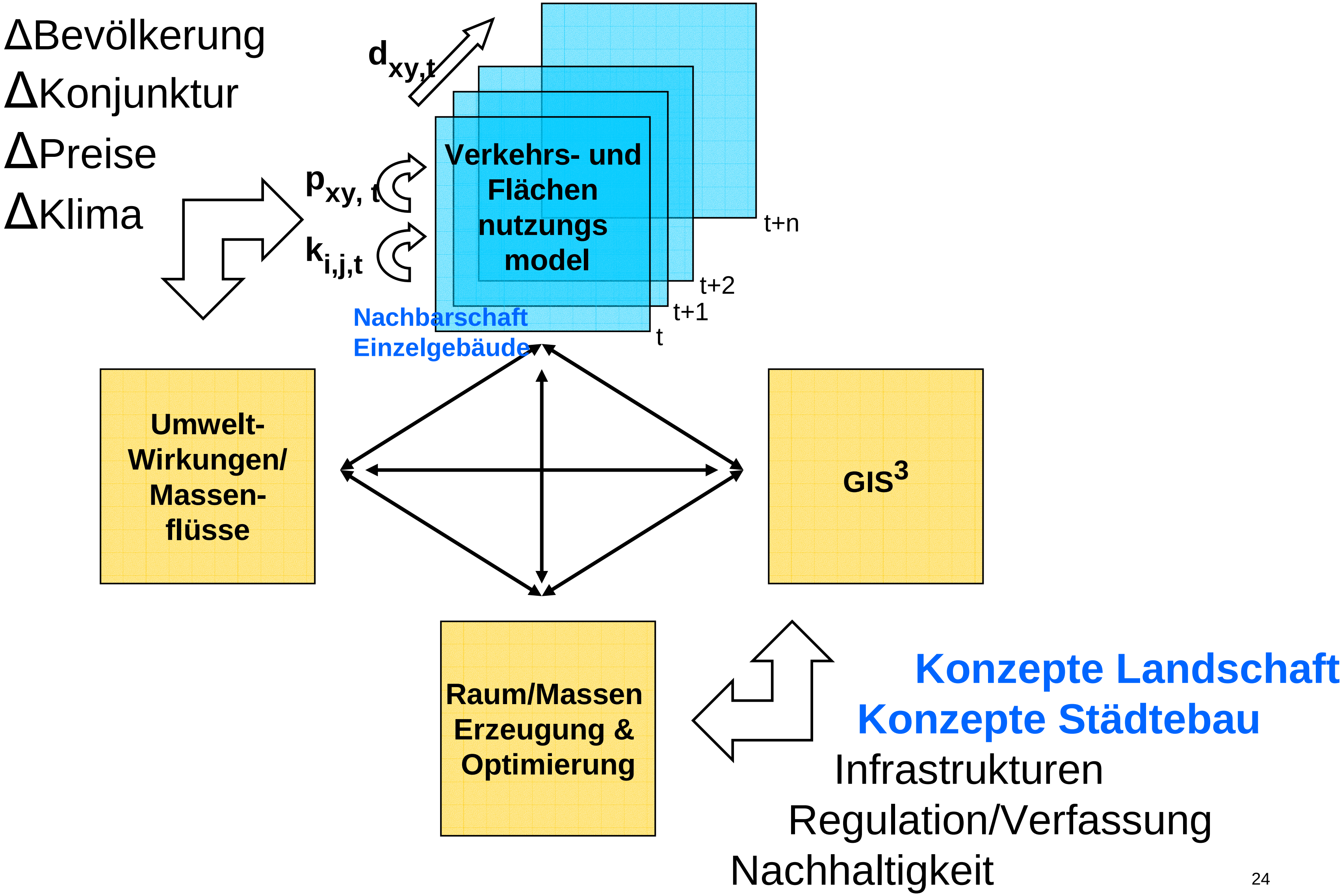
- Estimation of the underlying choice models
- Speed of computation
- Interaction between persons
- Choice of activity schedule

What type of urban space is likely ?

Commuter sheds of biggest Swiss cities since 1970

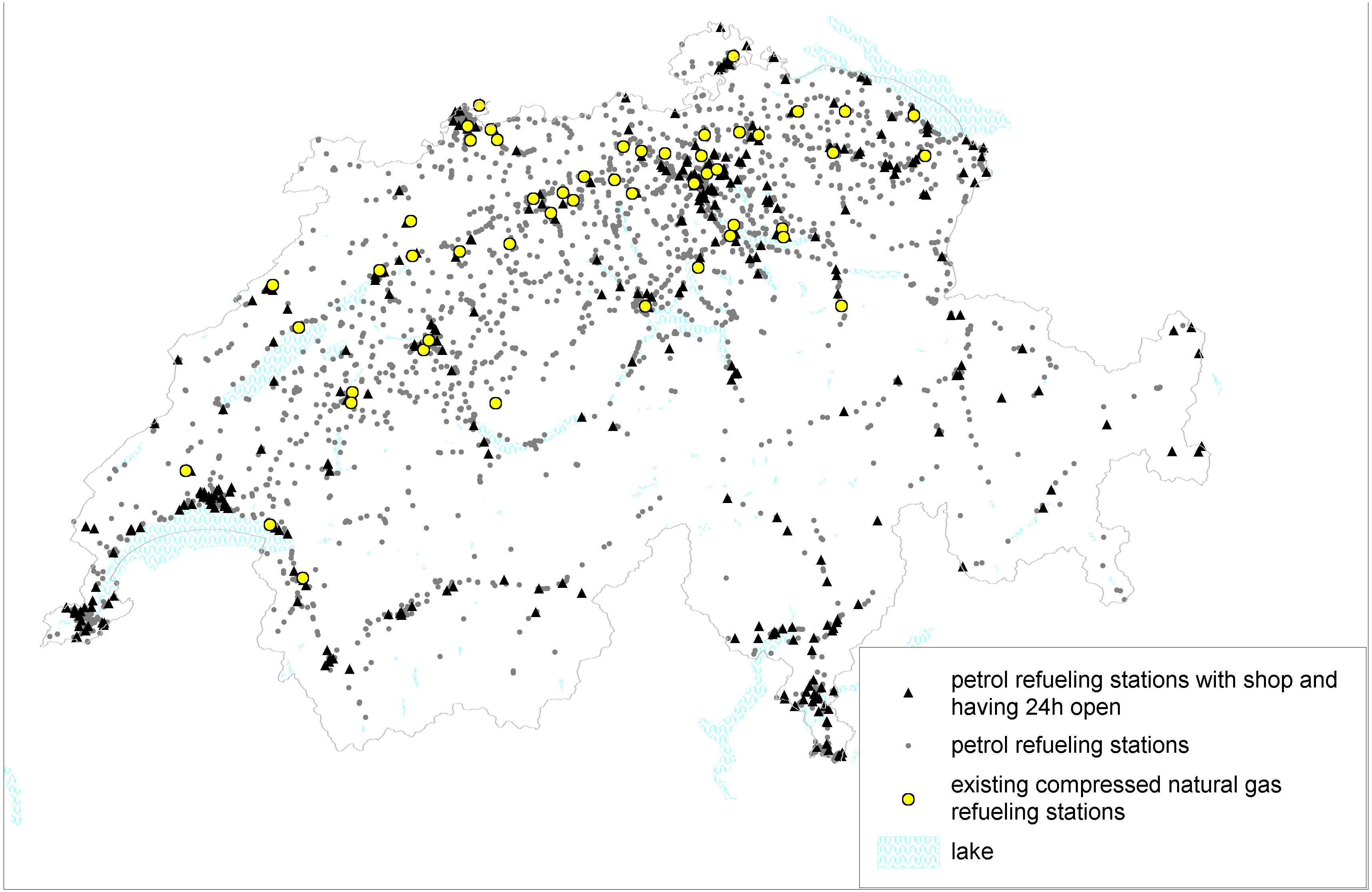


Integrated land use and transport models



Where to provide fuel ?

Current Swiss petrol stations



Problem (Simulated Annealing)

Find

min SC

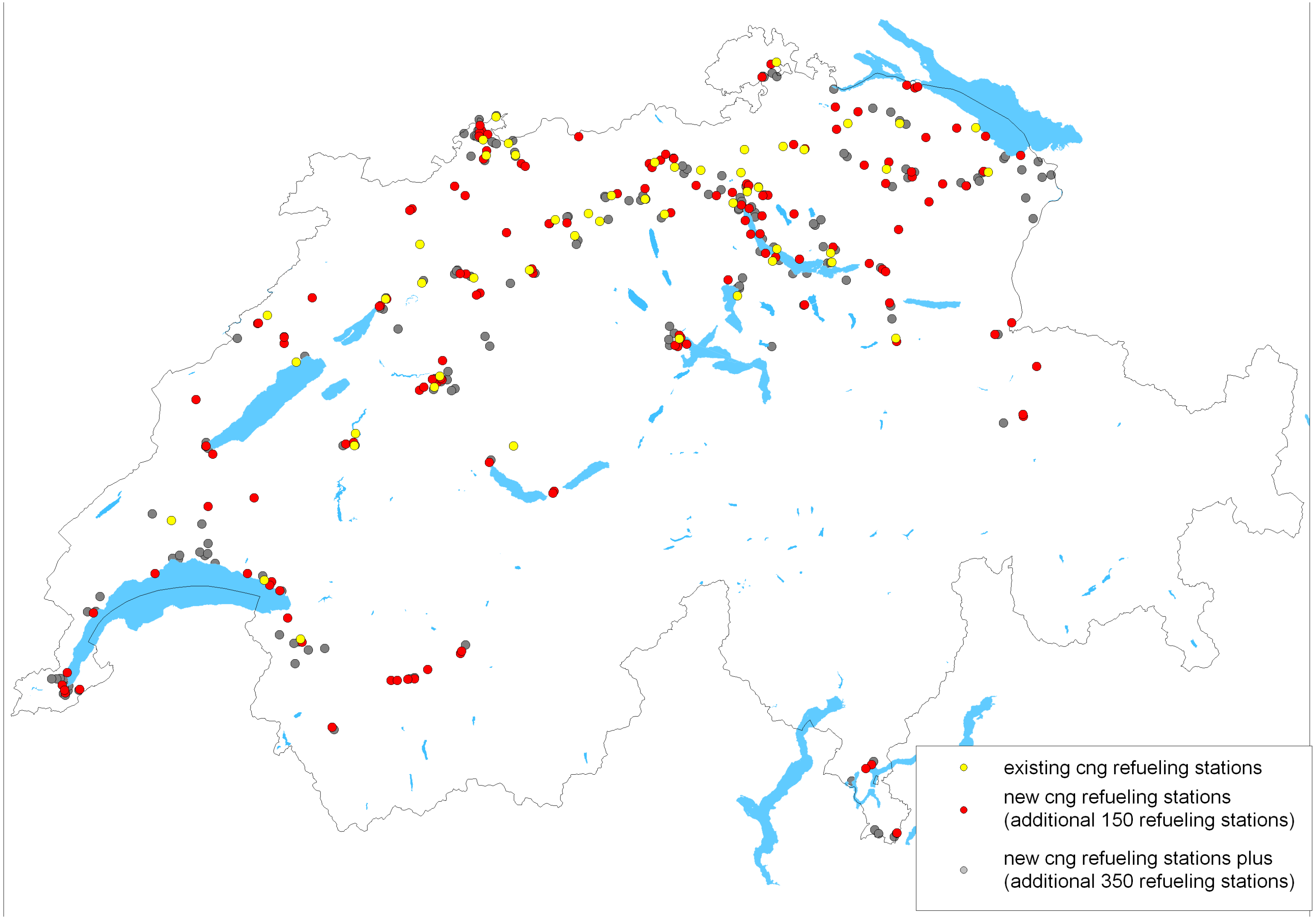
with

SC : Social costs (construction, operation. CO_2 reduction, car purchase costs, additional gas station profits)

s.t.

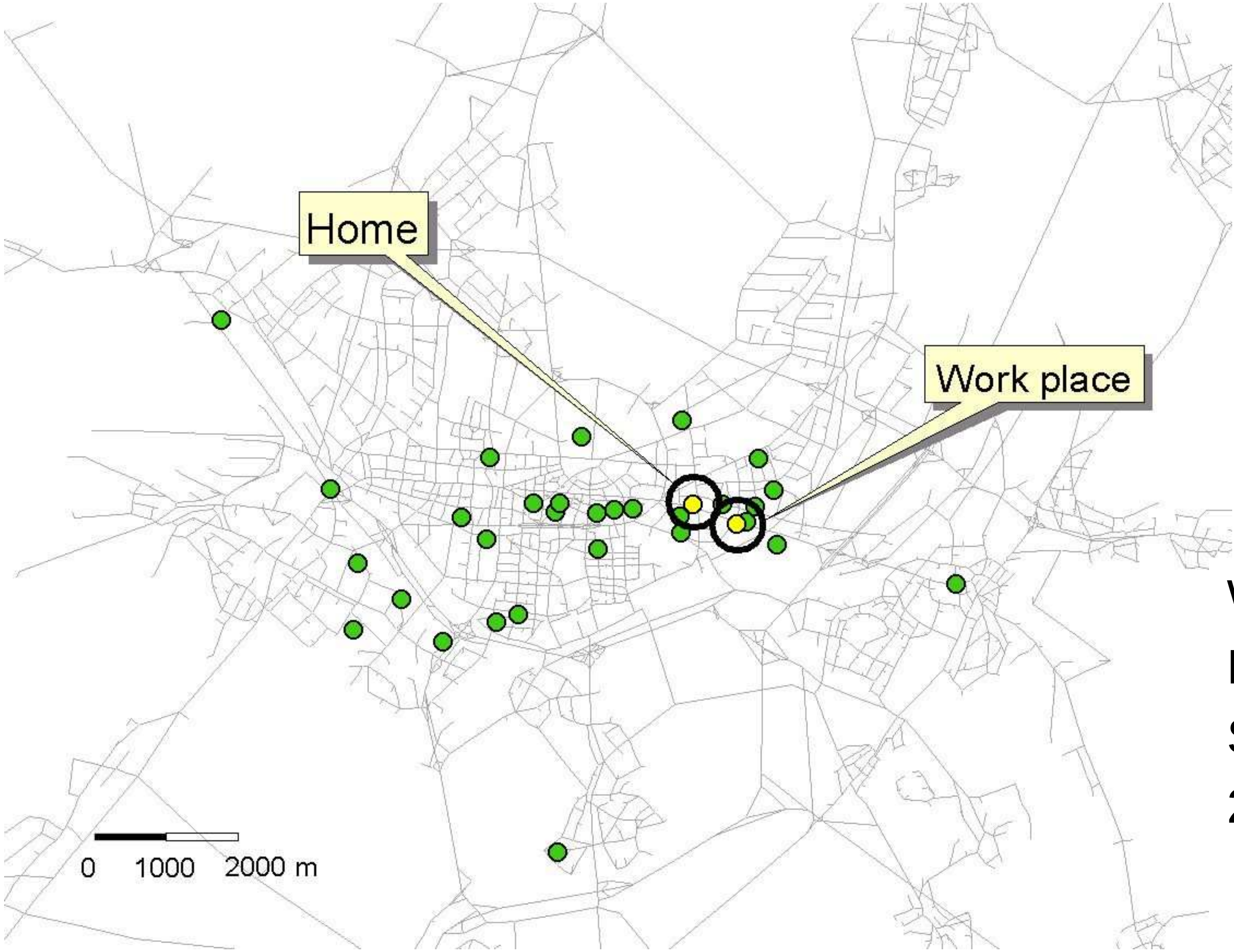
- Additional 300 compressed natural gas stations among the exiting locations
- Customer choice of gas stations
- Acquistion of additional CNG cars

The next 300 CNG stations



How much city does one need ?

Chosen locations during a six-week period



Women, 24

Full-time

Single

216 trips / 6 weeks

Schönfelder

12000761

Measurement approaches

Parametric:

- 95% confidence ellipse (assumption of normality)
- 95% inclusion geometries

Semiparametric:

- Positive probabilities of presence (Kernel density distributions)
- Shortest path network

Non-parametric

- Observed path networks

Inclusion geometries

Find:

$\min A_i(\beta_{i1} \ldots\ldots \beta_{in})$

s.t.

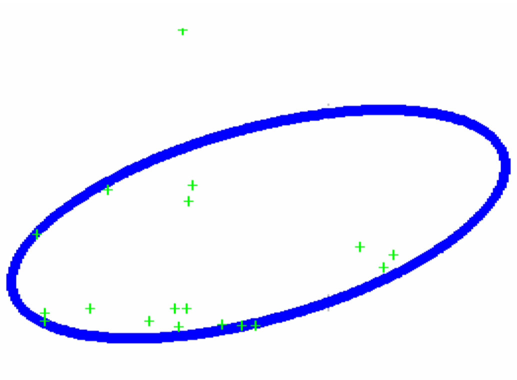
Area A_i covering p% of all observed points

with:

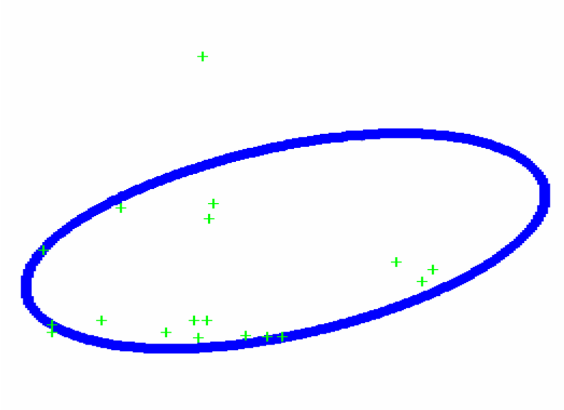
i	:	Type of geometry (Ellipse, bean, Cassini ...)
p	:	Share, e.g. 95%

Examples of inclusion geometries

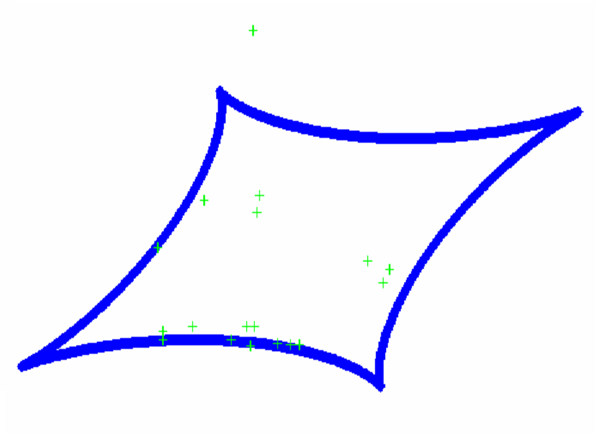
Ellipse



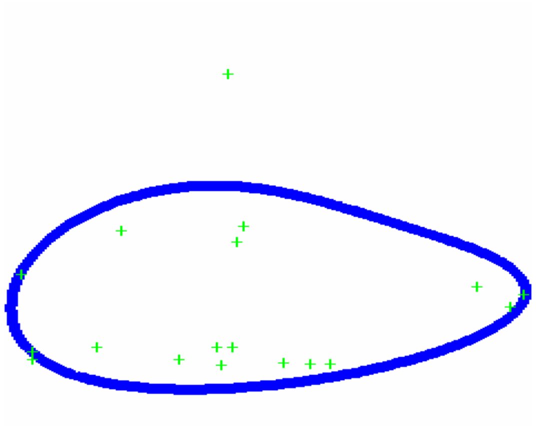
Superellipse 1



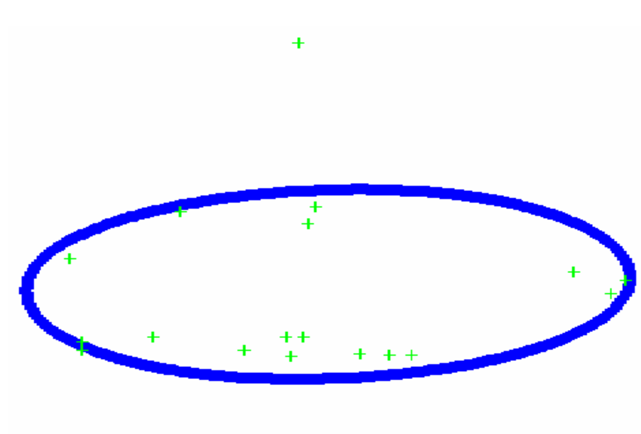
Superellipse 2



Bean

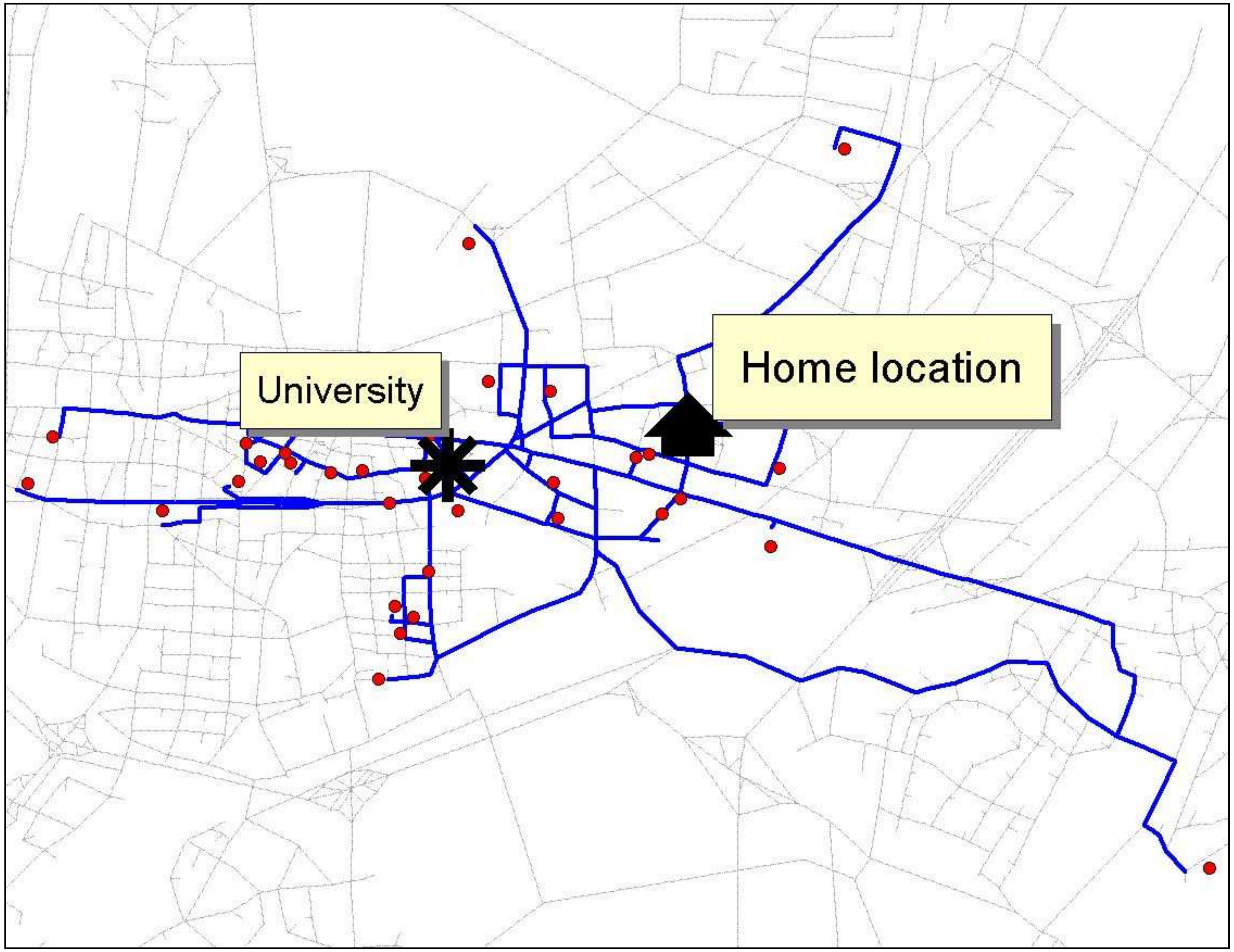


Cassini

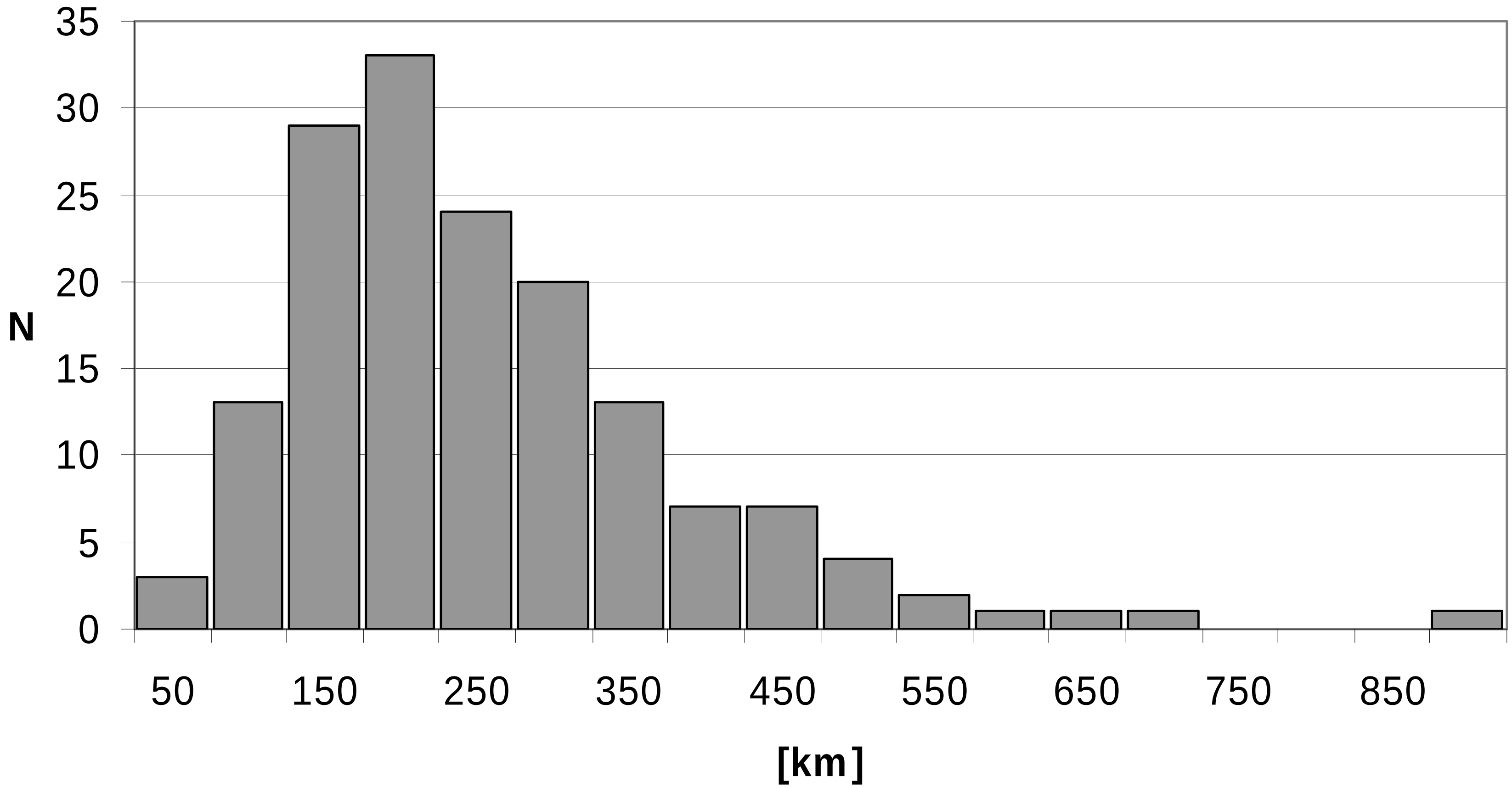


Vaze, Schönfelder and Axhausen, 2005

Shortest path network



Distribution of shortest path networks



Map matching

Problem:

Optimally match $3*10^6$ GPS observations (in less then 1 min)

s.t.

- Unknown errors of the GPS observations
- Gaps in the GPS stream
- Known, but not localised errors in the map representation

Algorithm of Marchal

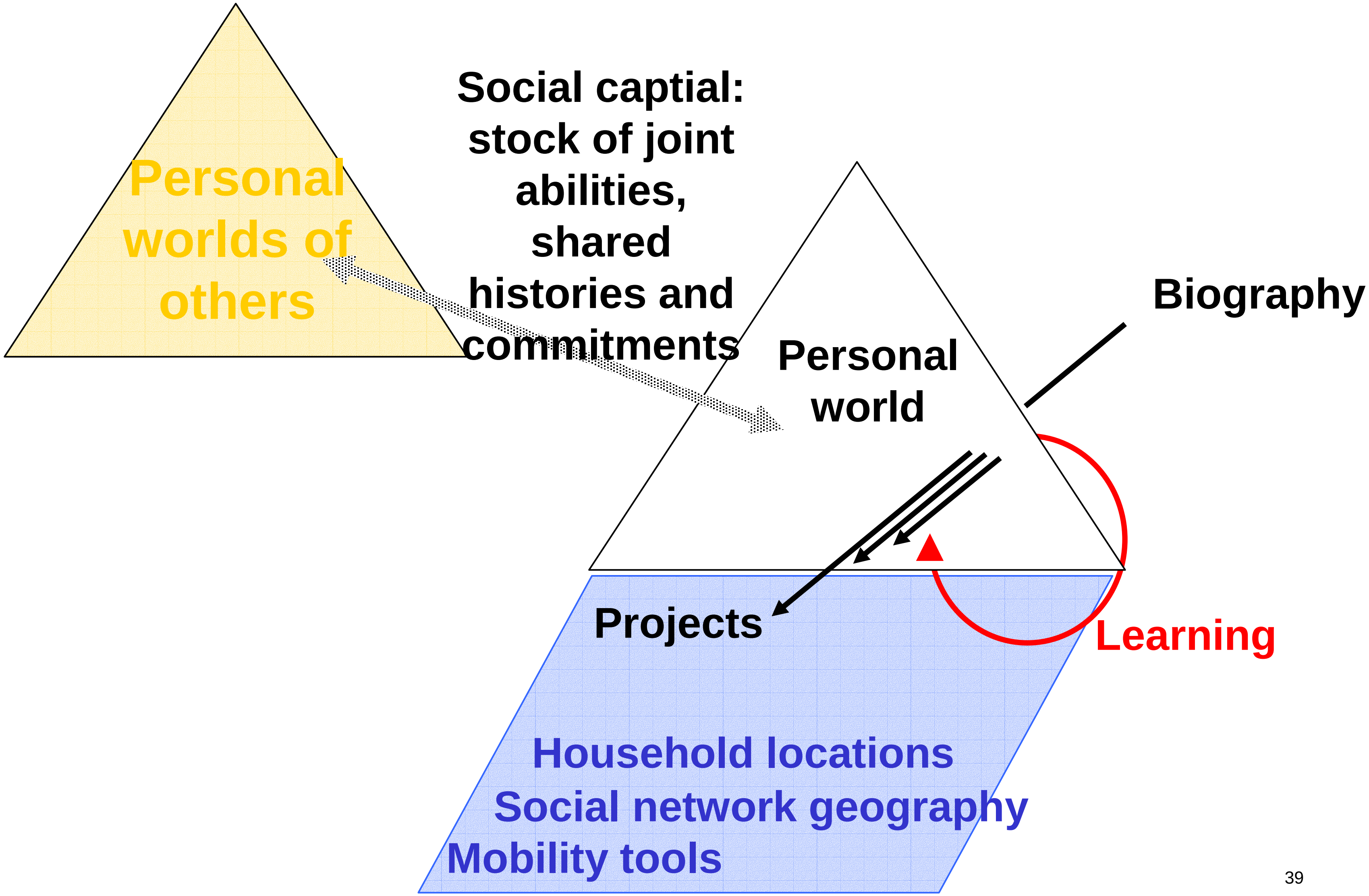
N	Accuracy [m/pt]		Accuracy [%]		CPU [s]	
	H	L	H	L	H	L
10	435.8	56.8	55.2	8.5	56	12
15	15.9	53.2	18.2	8.5	58	14
20	13.1	50.0	10.9	4.4	62	18
30	11.3	49.8	4.5	4.4	70	21
40	10.6	49.8	3.6	4.4	78	31
50	10.5	49.8	3.3	4.4	85	37
100	10.3	49.8	3.3	4.4	122	72

N: Number of branches; H(igh) and l(ow) quality map

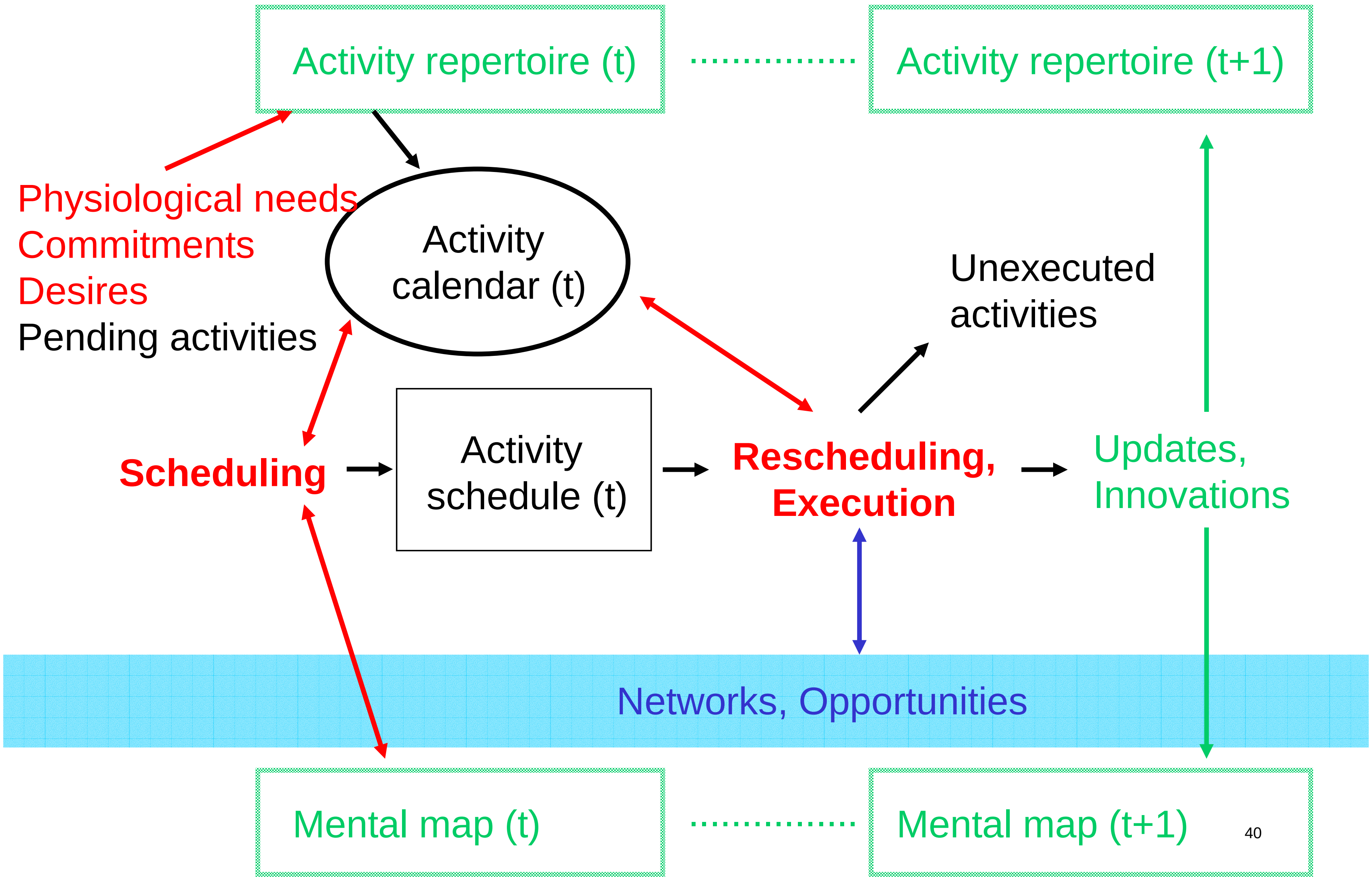
Marchal, Hackney and Axhausen, Forthcoming

Can we model agents/groups of agents ?

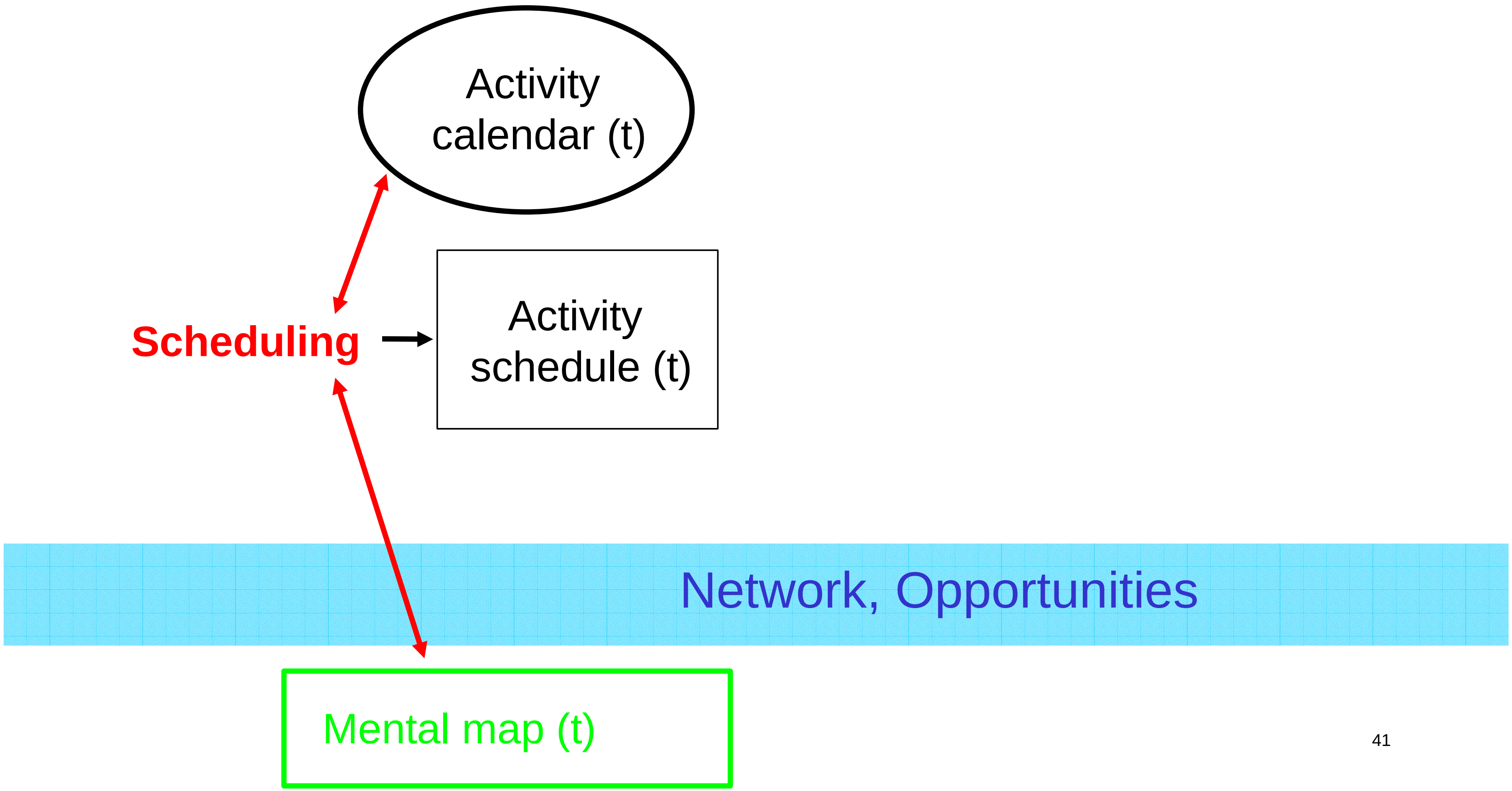
The individual in a dynamic social context



Modelling the personal daily dynamics



Scheduling


Activity calendar (t)
Scheduling
Activity schedule (t)
Network, Opportunities
Mental map (t)

Problem

Problem:

$$\max F = HUF = \sum_m U_m$$

with

$$U_m = \sum_i U_{total,i}$$

$$U_{total,i} = U_{dur,i} - c_{travel,i} - c_{wait,i} - c_{late,i} - c_{early,i}$$

s.t.

- Time windows
- Minimum times
- Resource constraints (car, time)

Approach: Genetic Algorithm (GA)

Large (partially discrete) solution space:

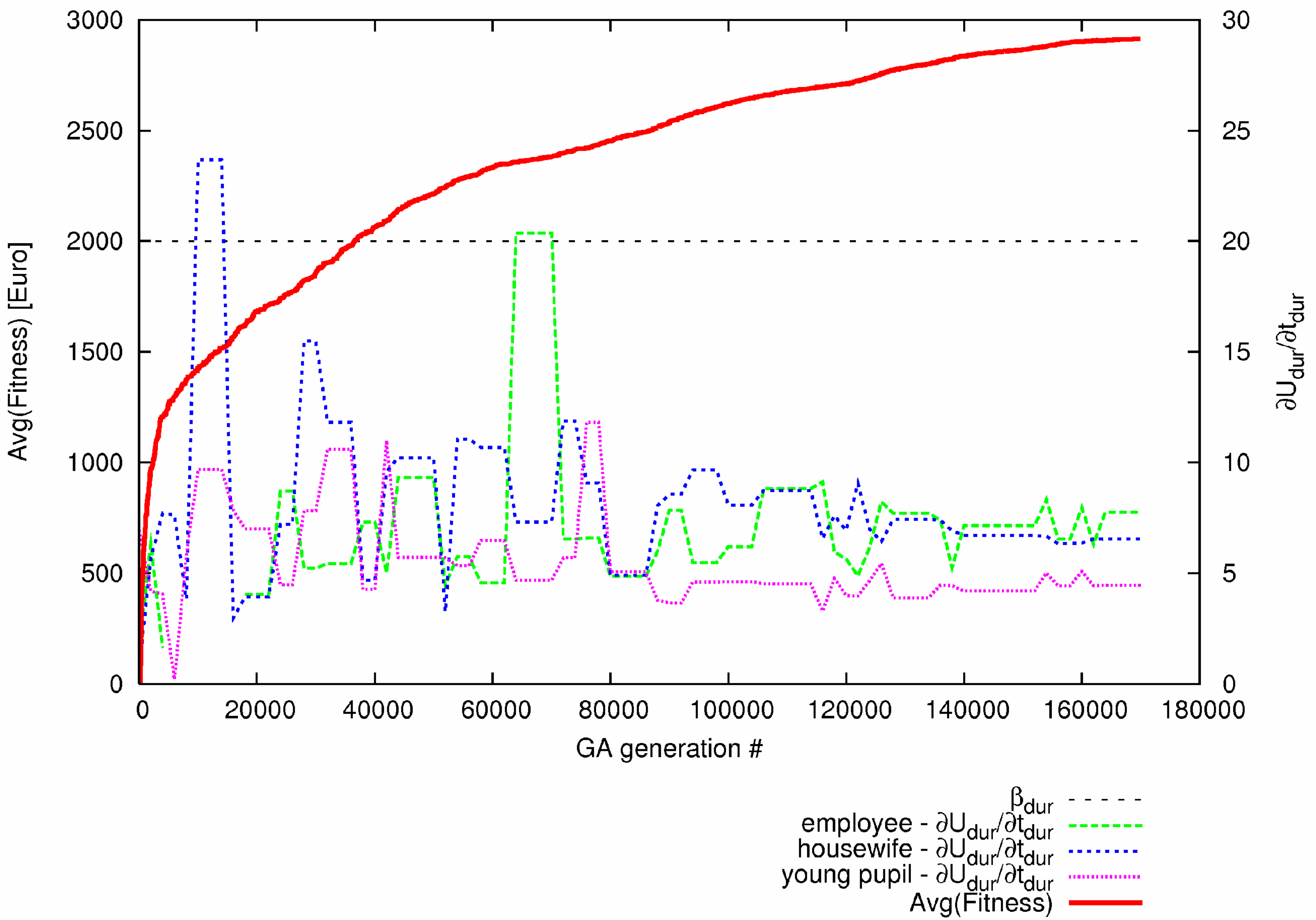
- 5 variables / activity (participation, timing, duration, location, mode)
- ~ 8 activities / agent
- 2-4 agents / household

- ~ 80-160 variables / household schedule

Large number of agents:

10^6 for Zürich

GA performance ~ 3 seconds/agent



Meister

Challenge

Performance of total system for 10^6 agents:

Relaxation of (~ 50 iterations)

- Scheduling of agents ($3 * 10^5$ sec)
- Network simulation ($3 * 10^2$ sec)
- I/O (10^2 sec)

-> Month of computing time

References

Carosio, A., C. Dolci and M. Scherer (2005) Erreichbarkeitsveränderungen in der Schweiz: Eine kartographische Darstellung, in K.W. Axhausen and L. Hurni (eds.) Zeitkarten Schweiz 1950-2000, Chapter 3, IVT and IKA, ETH Zürich, Zürich.

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Meister, K., M. Frick and K.W. Axhausen (2005) A GA-based household scheduler, *Transportation, **32** (5) 473 – 494.*

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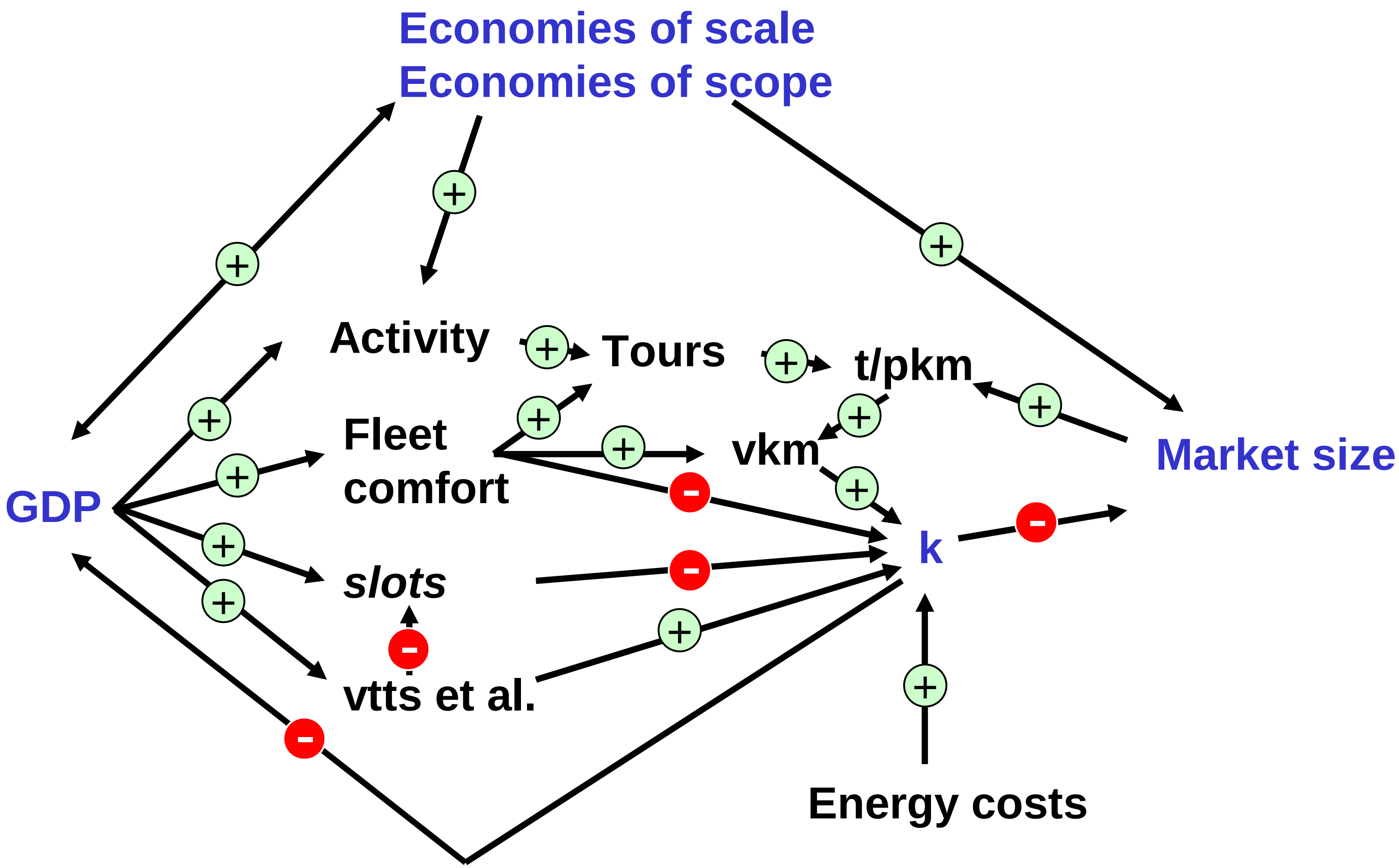
Vaze V.S., S. Schönfelder and K.W. Axhausen (2005) Optimization of continuous space representation for human activity spaces, *Arbeitsbericht Vekehrs- und Raumplanung*, **295**, Institut für Verkehrsplanung and Transportsysteme (IVT), ETH Zürich, Zürich

Hypothesis



Elasticity > 0
Elasticity < 0

Slots: possibilities to move goods or people For a given infrastructure and commercial and private fleet