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Modelling infrastructure gains: An experiment

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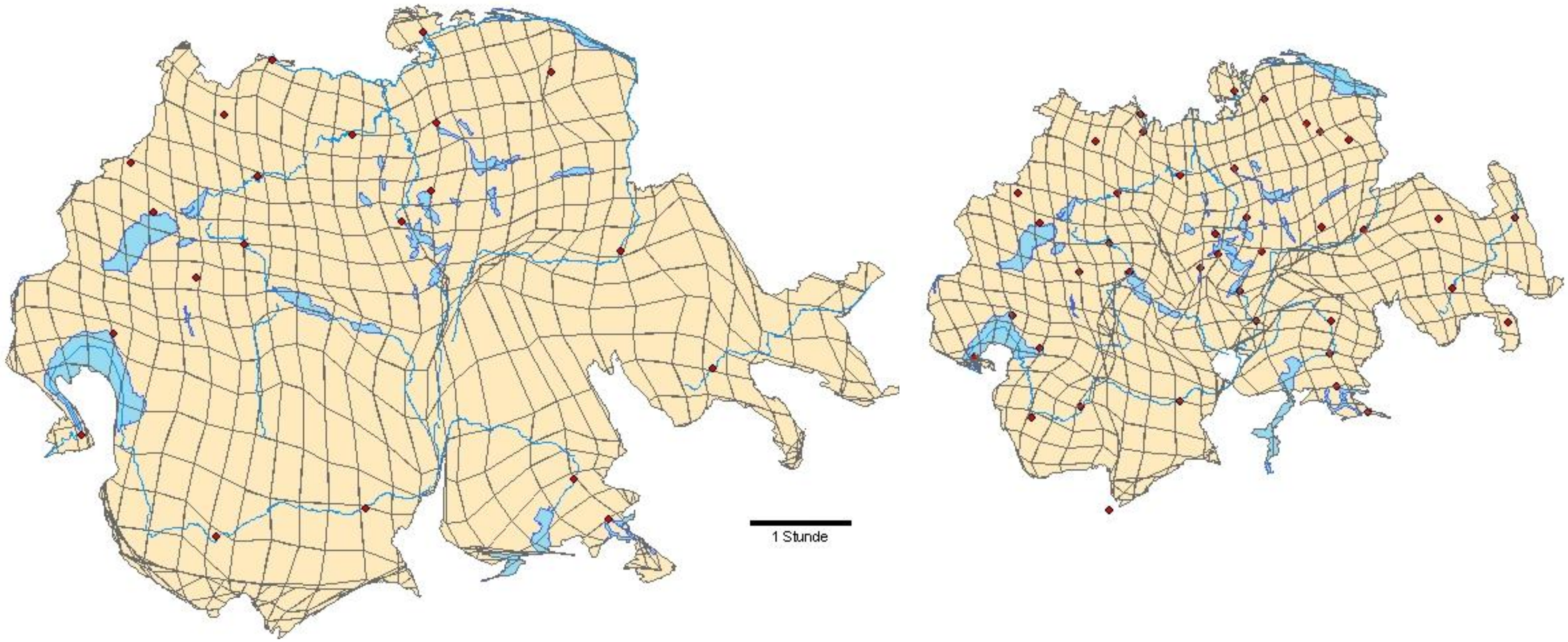
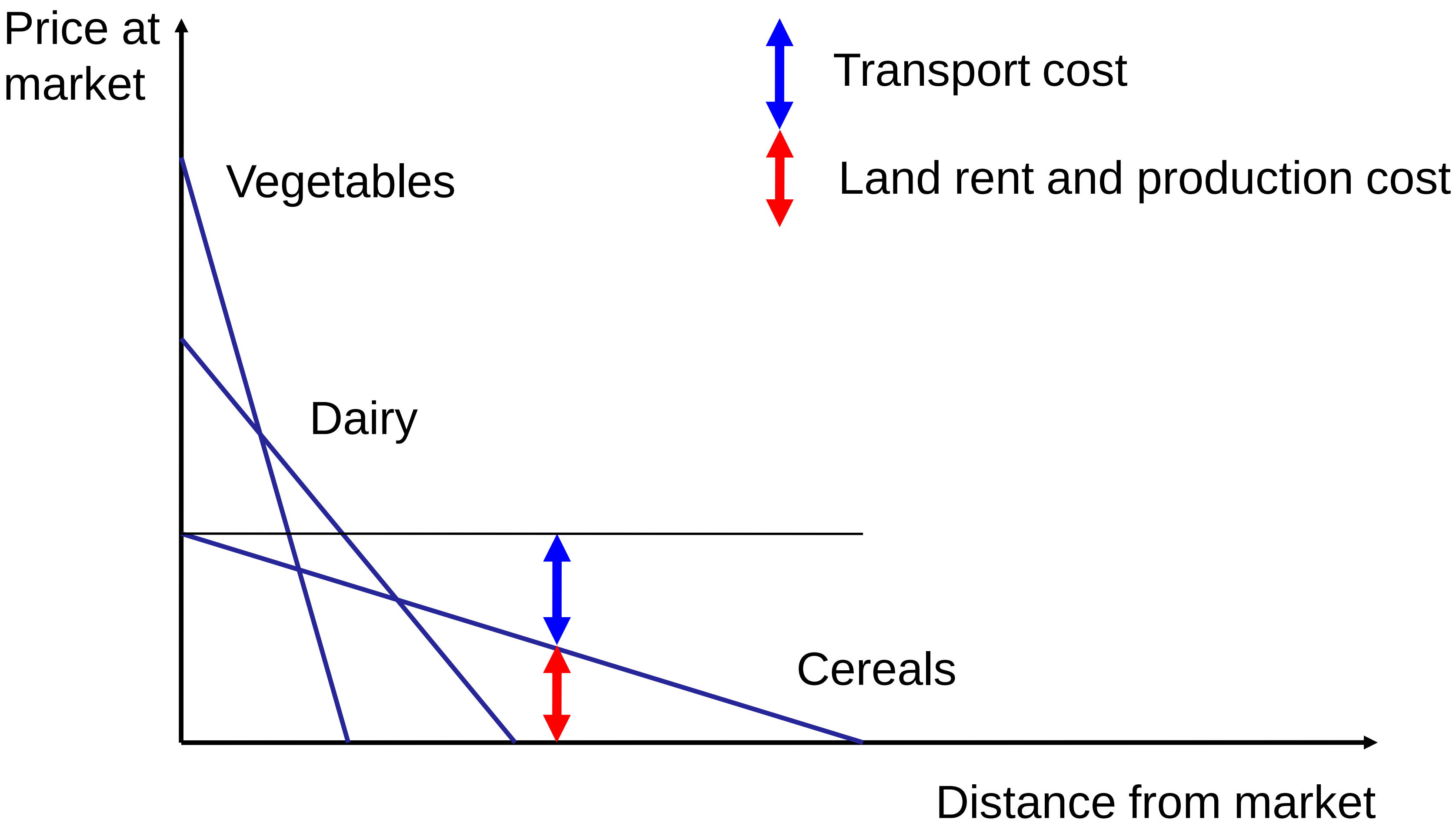
Road travel-time scaled Switzerland 1950 and 2000



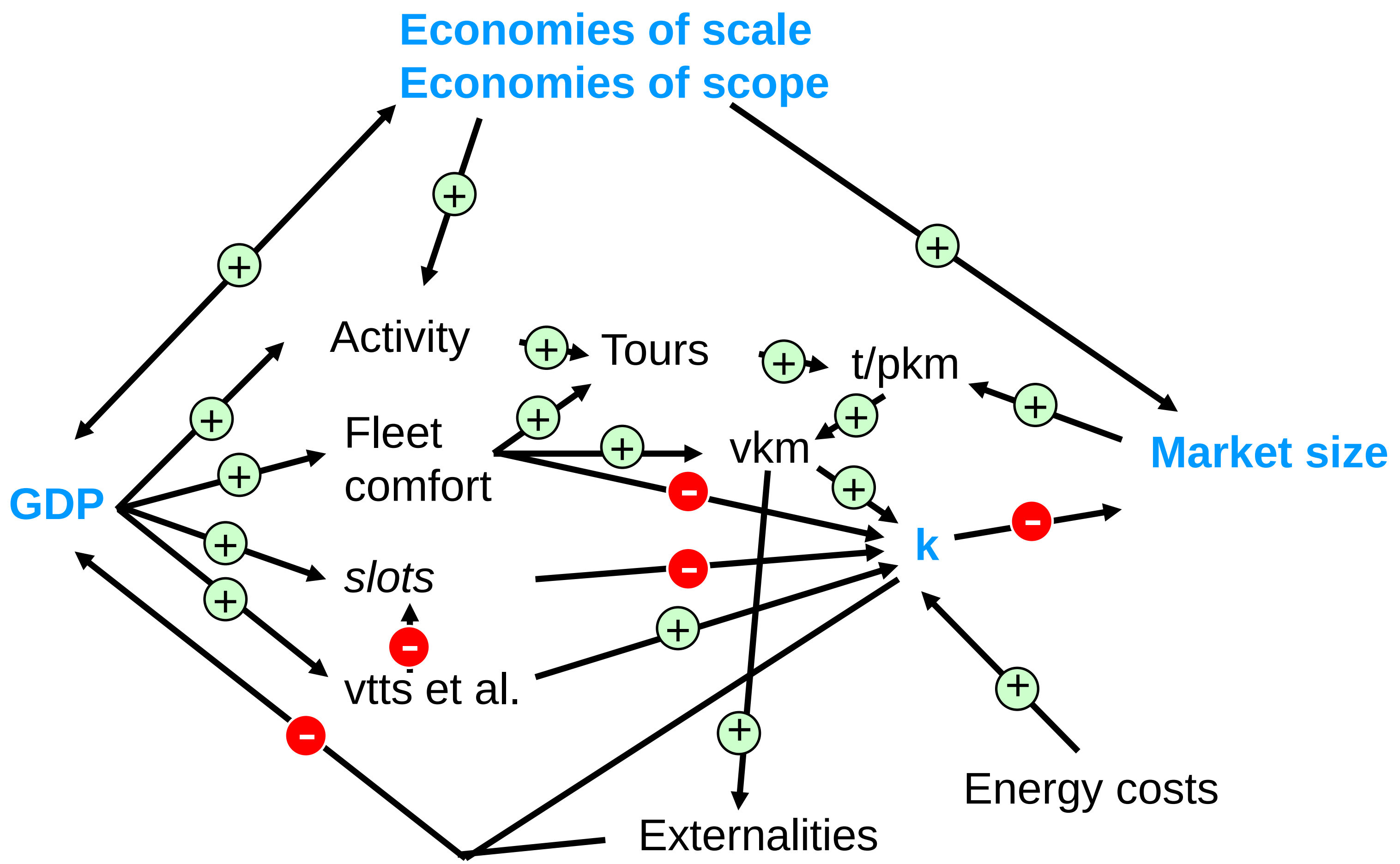
Scherer, 2004

Von Thünen‘s model of land use for the isolated city



Based on Von Thünen (1910)

Size of goods markets and productivity: A hypothesis



+ Elasticity > 0
– Elasticity < 0

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

Short-term benefits and costs after an improvement

Public	Private	Firms	Land owners
	Lower travel times Higher reliability Smaller scheduled delays	Lower logistics costs	

Medium-term benefits and costs after an improvement

Public	Private	Firms	Land owners
Higher externalities Higher maintenance costs Higher transit subsities Larger fuel tax receipts	Mode choice change Higher VMT Larger selection More out-of-home activities Higher travel expenditures	Changed customer structure	Changed (higher) imissions

Long-term benefits and costs after an improvement

Public	Private	Firms	Land owners
More competition More innovation Higher growth More social capital	New residential location Better job match Higher incomes Lower consumer prices Lower transit supply More stable social networks	Better match of employees Higher productivy More competition for employees and customers	Higher land prices

Loosers

Firms:

- Not enough capital/cash flow to expand/adapt
- Not enough expertise to innovate/adapt

Individuals:

- Not enough education to adapt
- Not enough savings/cash flow to adapt
- Not enough degrees of freedom to adapt

- Loss of “vicinity”
- Loss/increased generalised costs of the vehicle-less option

Ideal model: Activity scheduling

- Number and type of activities
- Sequence of activities
  - Start and duration of activity
  - Composition of the group undertaking the activity
  - Expenditure division
  - Location of the activity
    - Movement between sequential locations
      - Location of access and egress from the mean of transport
        - Parking type and location
      - Vehicle/means of transport
      - Route/service
      - Group travelling together
      - Expenditure division

Ideal model: Individual long(er) term choices

- Social network geography
- Social commitments
- Amount and type(s) of occupation

  - Working hours
  - Work location(s)
  - School location
  - Home location

    - Mobility tools
    - Discount cards
    - Season tickets
    - Vehicles (by body type, fuel, energy efficiency)

Ideal model: Supply-side long(er) term choices

- Network links and capacities
- Housing
- Office and factory space
- Firm structure and size

  - Logistics system choice
  - Production technology and scale
  - Public transport lines and service frequeny

    - Firm location(s)
    - Distribution channel(s)
    - Service points (stops and stations)
    - Prices

Cost-benefit analysis: SN 641 820 ff - benefits

Change in:

- Travel time
- Reliability
- User operating costs
- VAT income change of public transport firms

- Accidents
- Noise
- Emissions (local and global)
- Soil sealing
- External costs of energy use for infrastructure operations
- Landscape impacts

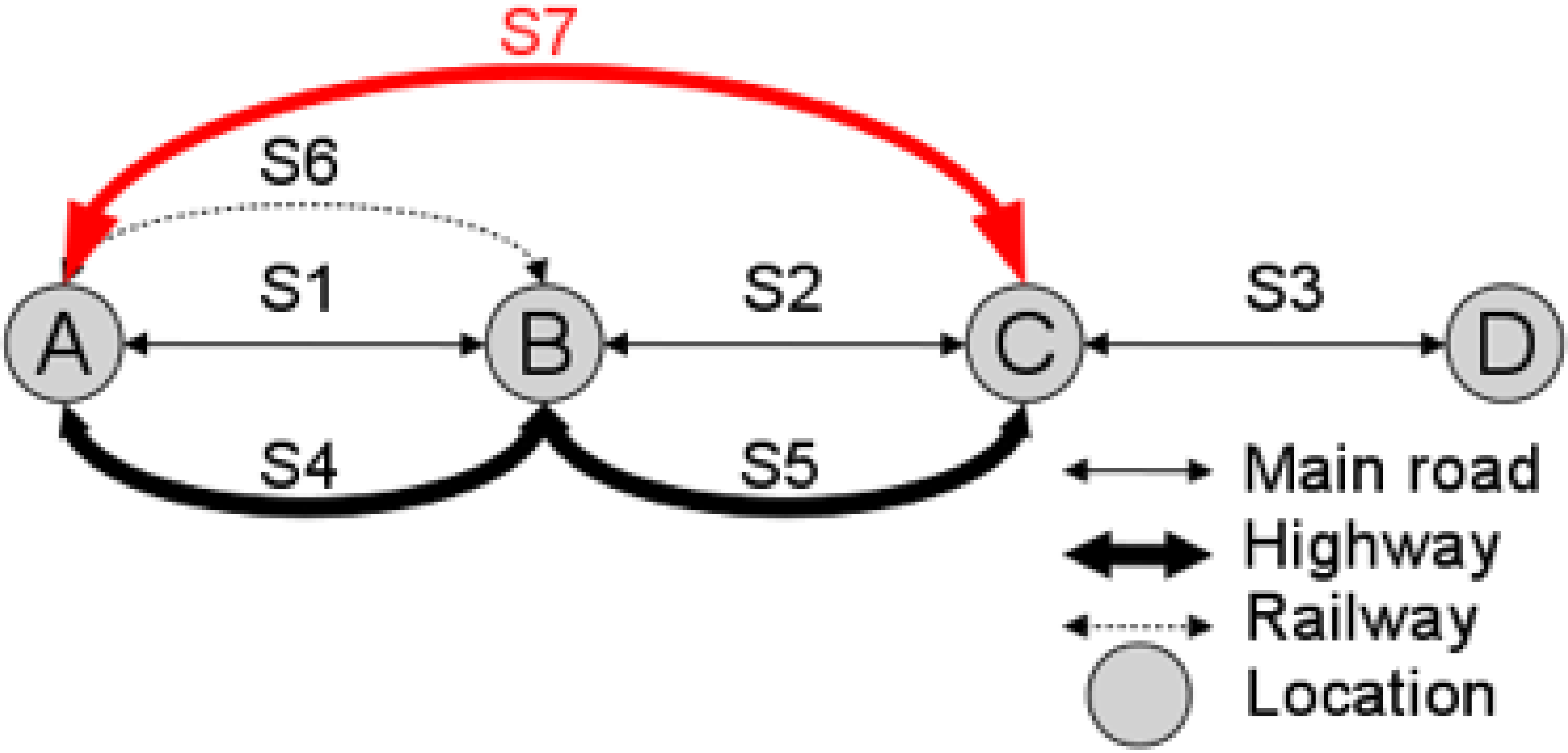
Research questions for MiniStadt: An agent-based model

- Can you capture the total benefits with travel time savings alone ?

- Construct the simplest necessary model
- Find plausible parameter set

- Experiment with various degrees of freedom of adaptation

MiniStadt: Form (including additional link S7)



MiniStadt: Choice dimensions

1000 agents returning home

- Work locations (1)
- Residential locations (3) with 600 homes each
- Time slots (24 of 5 minutes)
- Connections/routes (15/17)

MiniStadt: Utility formulation

Systematic utility of a connection:

Systematic utility of a departure time:

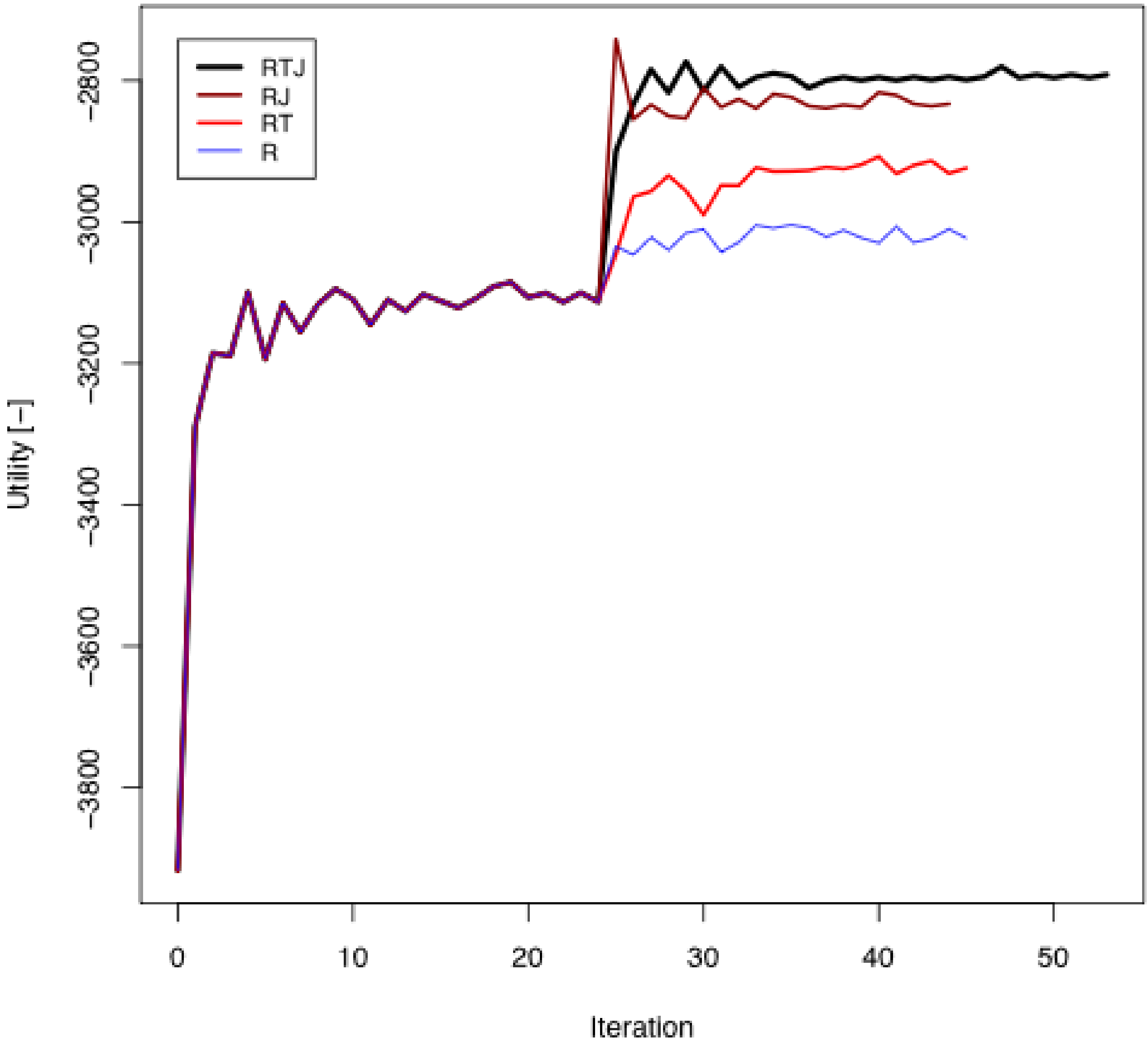
Systematic utility of a residential location:

MiniStadt: Experiments

Four experiments starting from RTD before equilibria:

- Connection (R)
- Connection * time (RT)
- Connection * destinations (RD)
- Connection * time * destinations (RTD)

MiniStadt: Convergence



MiniStadt: Occupancy rates

Experiment	B		C		D	
[%]	High	Low	High	Low	High	Low
RTD	76	8	9	59	0	15
RT	82	6	3	64	0	12
R	82	6	3	64	0	12
Before	82	6	3	64	0	12

Source: Zöllig and Axhausen, 2010

MiniStadt: Changes

	ΔRTD	ΔRT	ΔR
∑Travel time [min]	-1187	-1647	-1505
∑Travelled distance [km]	874	0	0
Accident costs [sFr/a]	-479’100	-472’700	-154’500
Traffic noise costs [sFr/a]	9’800	4’600	2’400
Air pollution costs [sFr/a]	26’500	13’600	7’200
Climate costs [sFr/a]	5’700	2’700	1’400

Source: Zöllig and Axhausen, 2010

MiniStadt: Utility gains

	ΔRTD	ΔRT	ΔR
ΔEMU	303	167	159
∑ External costs	-437'100	-451'800	-143'400
ΔV_{routes}	69	111	103
ΔV_{time}	74	53	-15
$\Delta V_{destination}$	133	-	-
ΔRealised utility	276	165	87

Source: Zöllig and Axhausen, 2010

What next ?

- Enrich the models
  - Add time, location choice (and reliability impacts)
  - Build full land user transport models

- Add winner/looser analysis

- Adopt (monetarised) EMU as measure of user benefit

More information

www.ivt.ethz.ch

www.matsim.org

References

Von Thünen, J.F. (1910) Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie, G. Fischer, Jena (reprint of the 1826 original)

Zöllig, C. and K.W. Axhausen (2010) How to model the gains from infrastructure investment?, *Arbeitsberichte Verkehrs- und Raumplanung*, **617**, IVT, ETH Zurich, Zurich.

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MiniStadt: Procedure

1. Load the initial conditions and set the number of iterations n = 0.
2. Calculate M, the number of agents deciding, as number of agents/(n + 1)2.
3. Sort the agents in descending order of their maximal potential utility gains.
4. Randomize the order of the M agents with the highest potential utility gains.
5. Let these agents decide one after the other and update the network after each decision.
6. Update the utilities across of all possible choices for all agents (choice set).
7. Calculate the maximal potential utility gain for each agent.
8. Calculate the system-wide statistics
9. Return to step 2 as long as n < 20 or sum of potential utility gains ≠ minimum of potential utility gains in the preceding iterations. Also stop iterating if no agent finds a better alternative, oscillation occurs, the maximum number of