Which AV revolution do we want?

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Which AV revolution do we want?

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Acknowledgments

S Hörl for the work on AV simulation

F Becker for the new mode choice and mobility tool models

P Bösch, F Becker and H Becker for the cost estimates (and many more)

Meyer, H Becker and P Bösch for the induced demand work

Basic assumptions

Basic definition

Social generalised costs is the sum of

individual generalised costs, i.e.

decison relevant generalised costs &

overlooked individual costs

And the

externalities caused

Basic assumption 1

Accessibility ~

Opportunities,
Speeds

Basic assumption 2

Traffic is a system of moving, self-organising

Queues

Basic assumption 3

The crucial short-term interaction between capacity, i.e. the

number of *slots*

for the desired speed and the

current demand

Basic assumption 4

Societies chose their

number of *slots*

By the

design/operation of the road/rail network

For the

desired speeds

Basic assumption 5

Travel demand (pkm or tkm) is a

normal good

i.e. it grows with

decreasing individual “generalised costs”

Basic assumption 6

Decision relevant generalised costs are the

sum of the risk and comfort weighted
monetary expenditure and the
time spent

Basic assumption 7

The travellers chose their

average decision relevant generalised costs

with their package of

locations (residence, work) and
mobility tools

Basic assumption 8

A person‘s travel demand is the

result of its activity participation

constrained by the currently

available time and money resources and **their chosen average generalised costs**

Basic assumption 9

A person‘s travel experience is the result of the

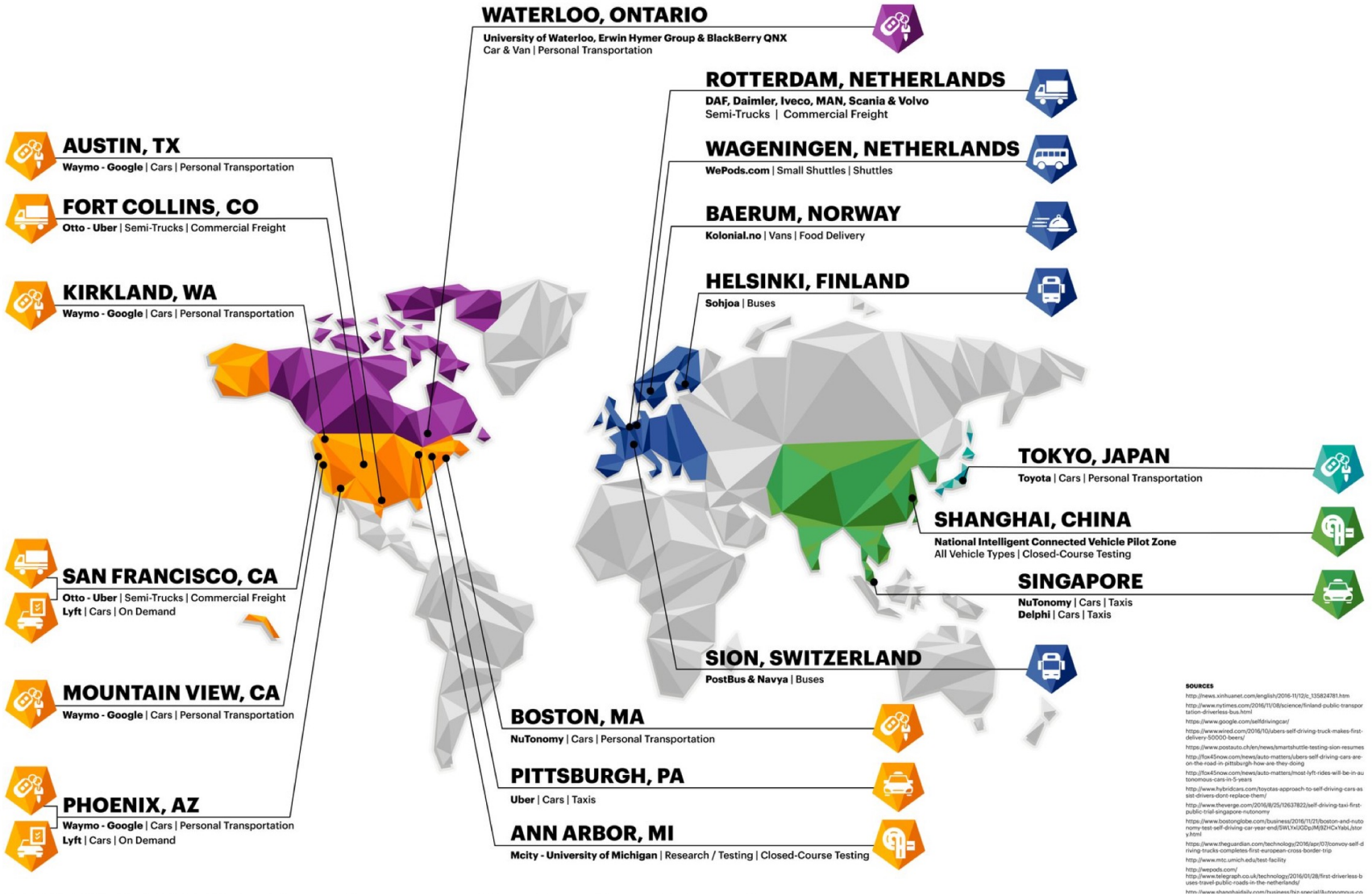
queues (joined or avoided)

And can be addressed by

mostly costly changes

When will they arrive?

On-going trials known to Accenture, February 2017



And maybe why not

Known hurdles

- Regulatory approval
  - Behaviour in dilemma situations
  - Restrictions to protect incumbents
    - Car manufacturers and service industries
    - Public transport industry
    - Taxi industry

- User acceptance
  - Reliance on taxi services (independence of third parties)
  - Use of pooled services
  - Acceptance of pooled taxi services
  - Replacement of the pride of ownership
  - Foregoing the mastery of the car

Known hurdles

- Non-user behaviour
  - Social norms for playing with AVs
  - Encoding social norms into the AV logic

- User/system behaviour
  - Number and extent of empty rides
  - Use for butler services (delivery, early positioning, etc.)

What are the current expectations?

What are the current general expectations?

- AV will reduce the generalised costs (time perception via increased comfort, monetary costs)
- AV will reduce them further through (pooled) taxis
- AV will increase the number of slots

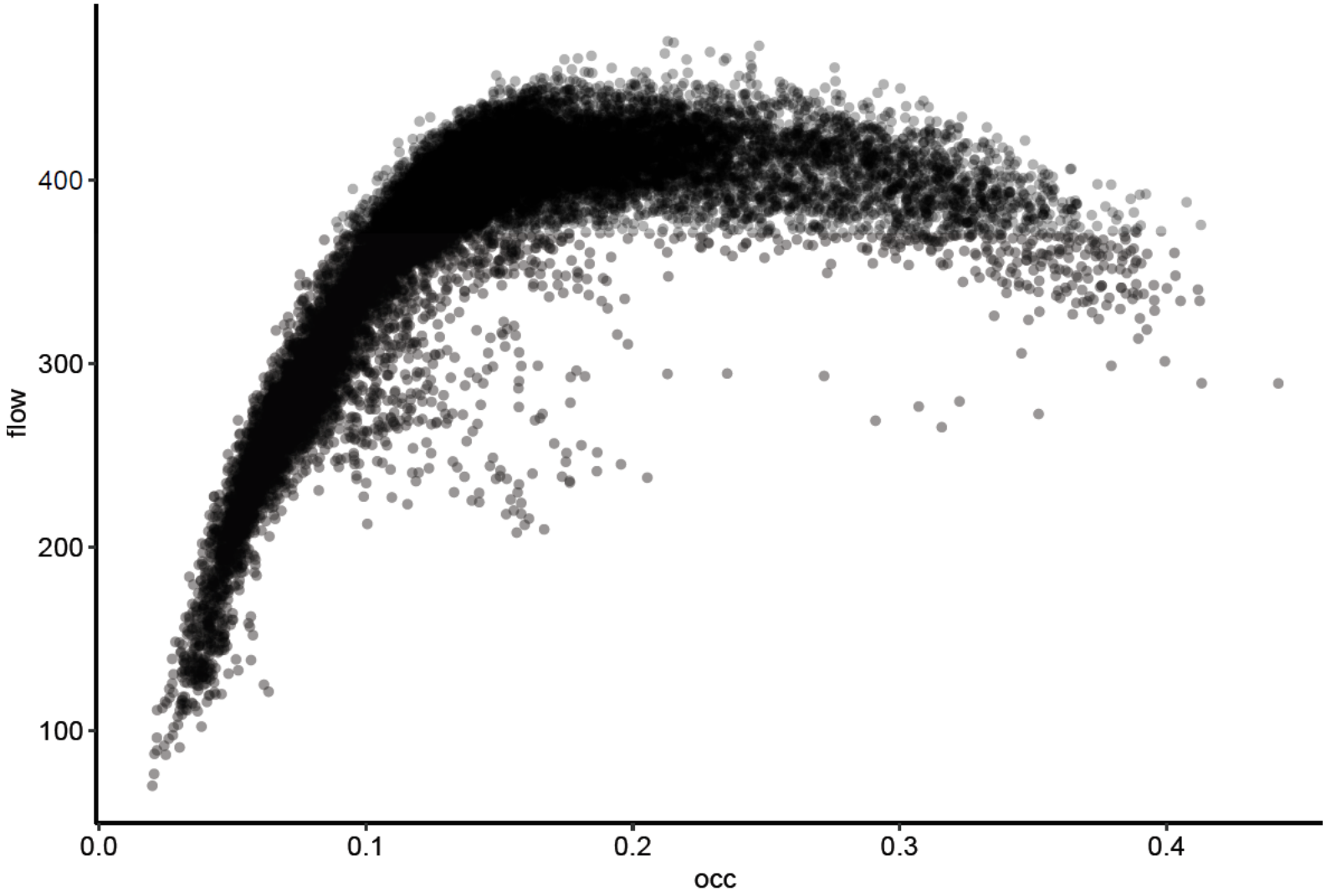
- AV will redistribute time by reducing shopping and pick-up/drop-off trips

- AV (vehicles/drones) will undermine the existing retail services
- AV will make most of current "public" transport superfluous

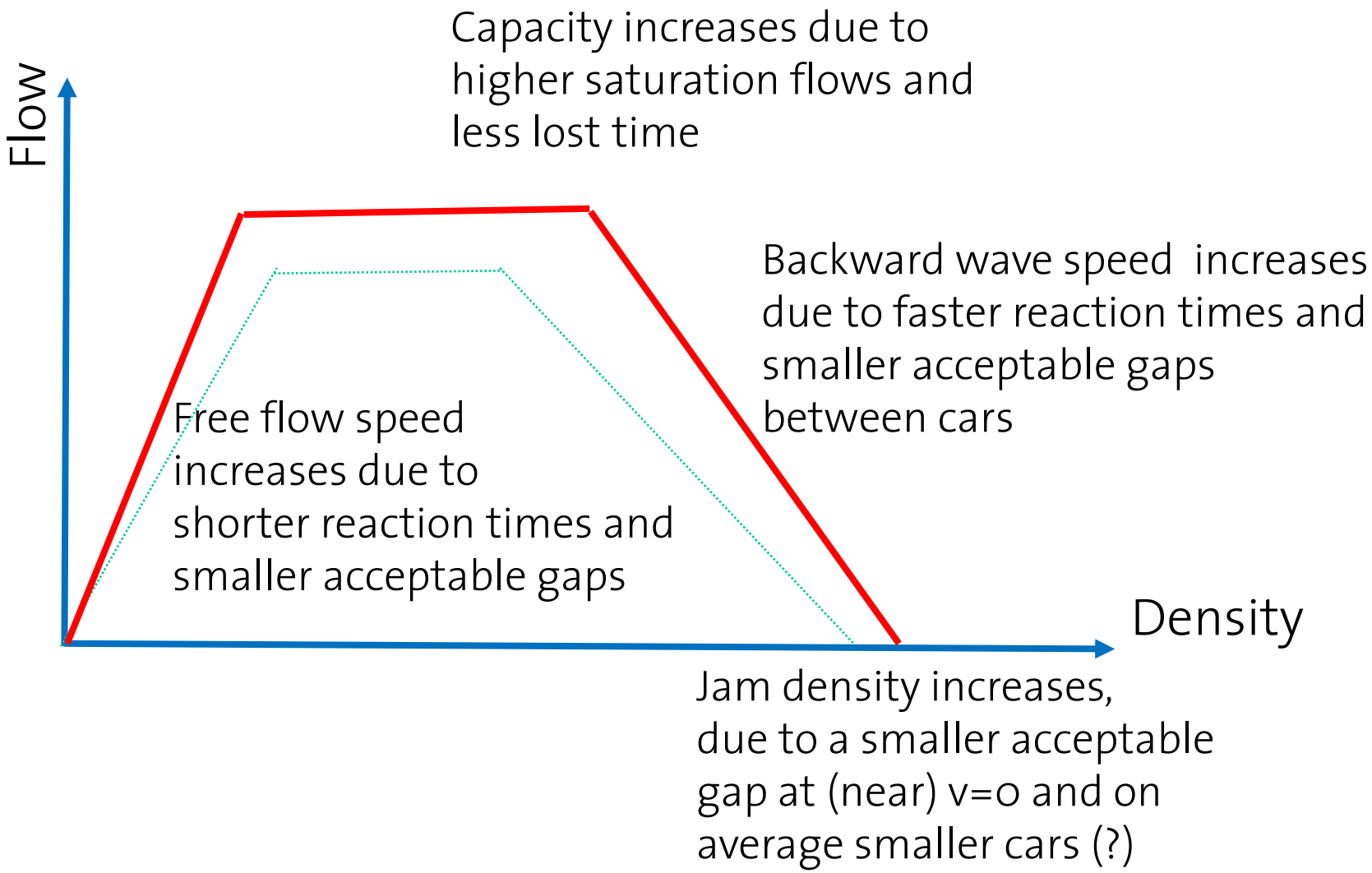
- AV will enable a new wave of urban sprawl

Capacity impacts

Current MFD example (one year data for Wiedikon, Zürich)

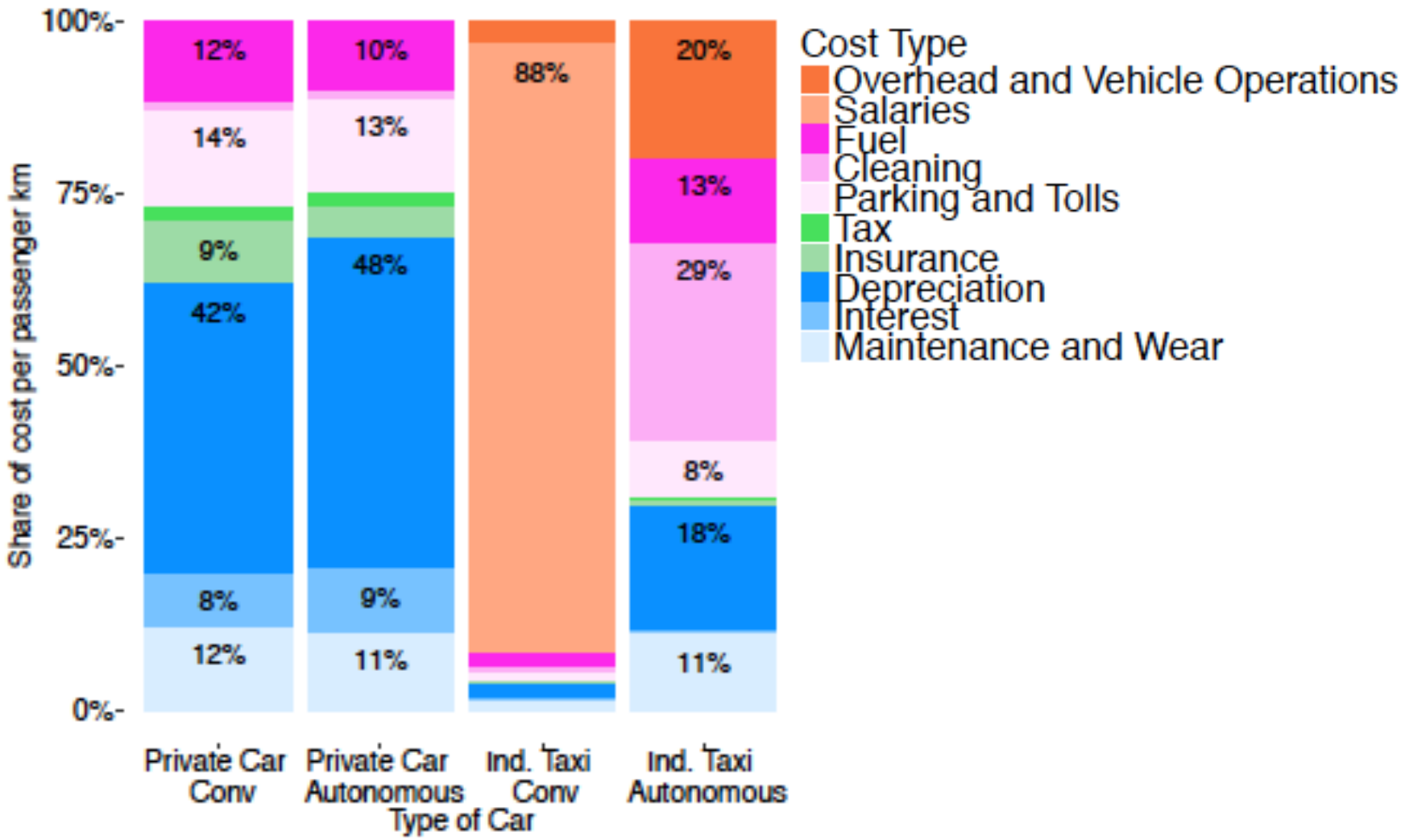


Capacity effects at the network level: MFD before/after

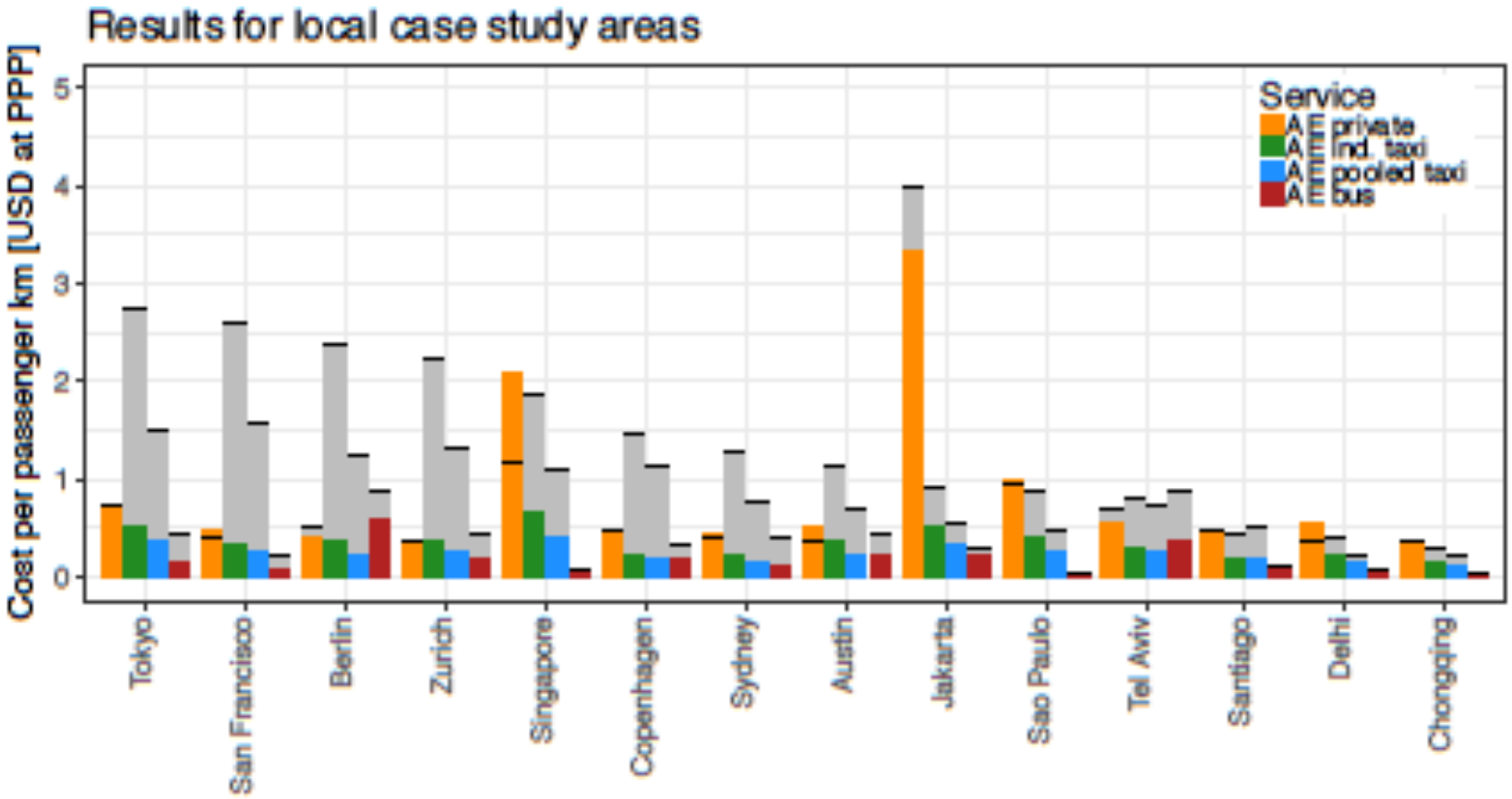


Basic trade-offs

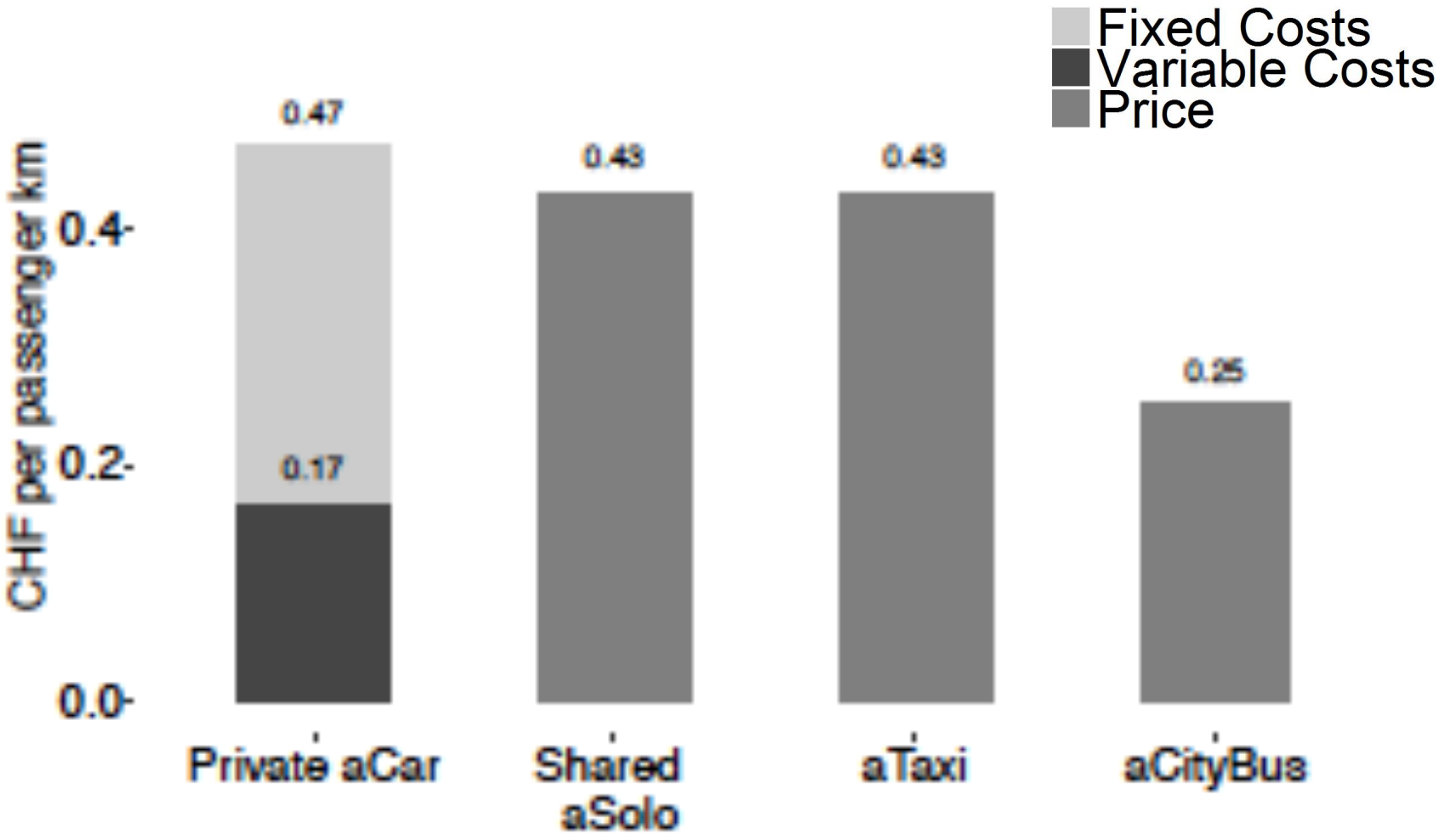
Updated full cost/pkm estimate (current occupancy levels)



Updated full cost/pkm estimates (local values)



Updated full cost/pkm estimate (current occupancy levels)



Some scenarios for a 2030 Level 5 vehicle future

Facets

- Market structure (monopoly, oligopoly, dispersed)
- Role and extent of public transport
- System target (system optimum, user equilibrium)
- Type of traffic system manager
- Road space allocation
- Share of autonomous vehicles

Scenario 1: As before

- Dispersed: Current owners replace their vehicles
- Public transport scaled down to the high capacity modes
- User equilibrium as system target
- Municipalities remain traffic system manager
- Road space allocation trends towards the AV, maybe even growth
- 100% share of small autonomous vehicles for safety reasons
- 100% share of electric vehicles for climate reasons

Scenario 2: Uber et al. take over

- Oligopoly of fleet owners
- Public transport scaled down to the high capacity modes
- System optimum via tolls and parking charges
- Operators negotiate slots with each other
- Road space allocation tends towards the slow modes
- 100% share of mixed size autonomous vehicles for cost reasons
- 100% share of electric vehicles for climate reasons

Scenario 3: Local transit new

- Monopoly, the locally owned operator expands into small vehicles
- Larger vehicles and hub-operations are encouraged
- System optimum routes are allocated over the days
- Local fleet operator is the traffic system manager
- Road space allocation unchanged
- 100% share of mixed size autonomous vehicles for cost reasons
- 100% share of electric vehicles for climate reasons

How to enable the mobility of low income travellers?

- Today
  - Public covers the fixed costs, especially of railways, but also of busses
  - Across-the-board operational subsidies
    - Lack of means-testing
    - Low price season tickets/fares
  - Operational support via priority at signals and road space allocation

- Future, when each kilometre is tracked and chargeable
  - Income-adjusted rebates ?
  - Income and work-distance adjusted rebates ?
  - Fixed free kilometre budget ?

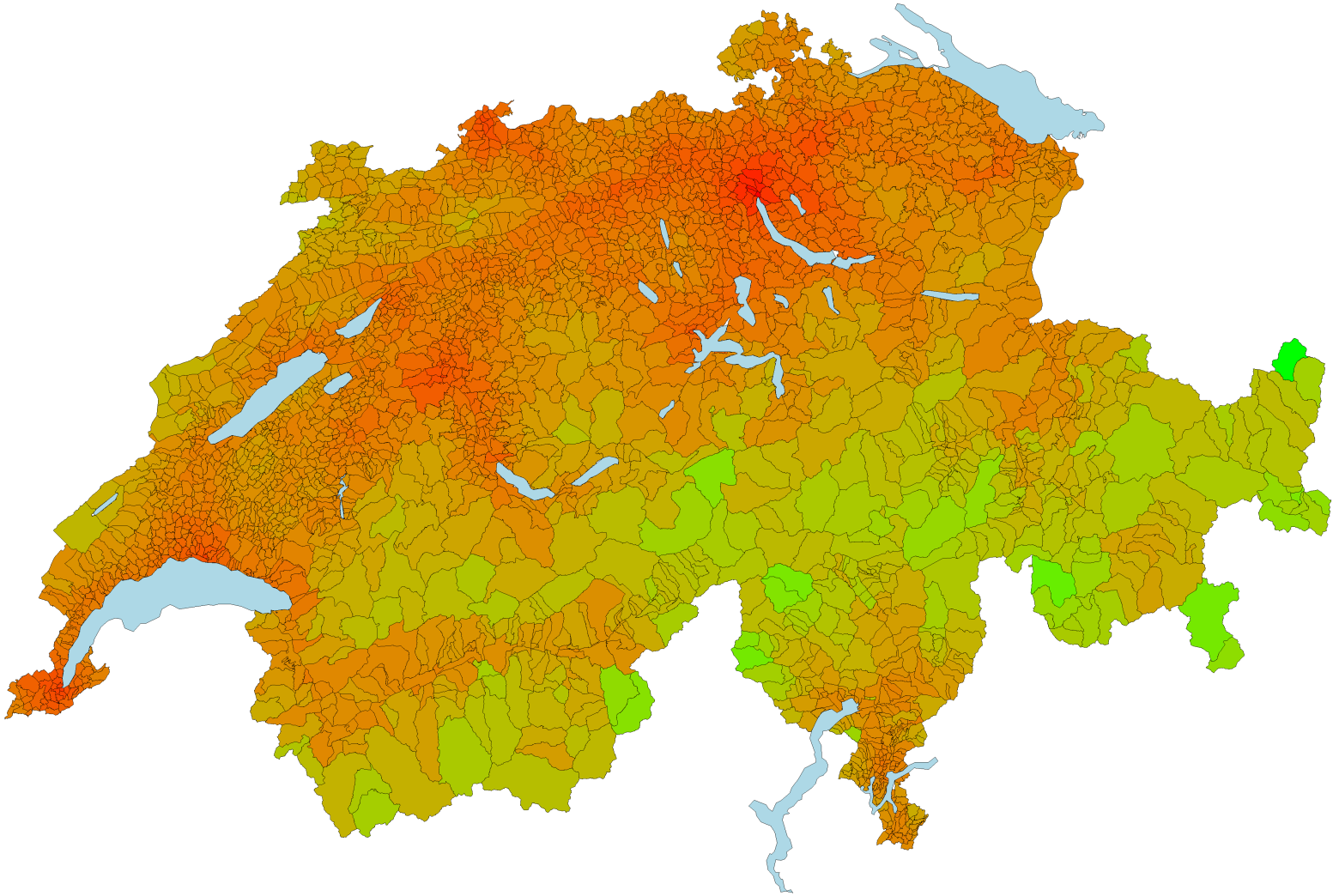
Induced demand by AVs

Induced demand elasticities from a pseudo-panel

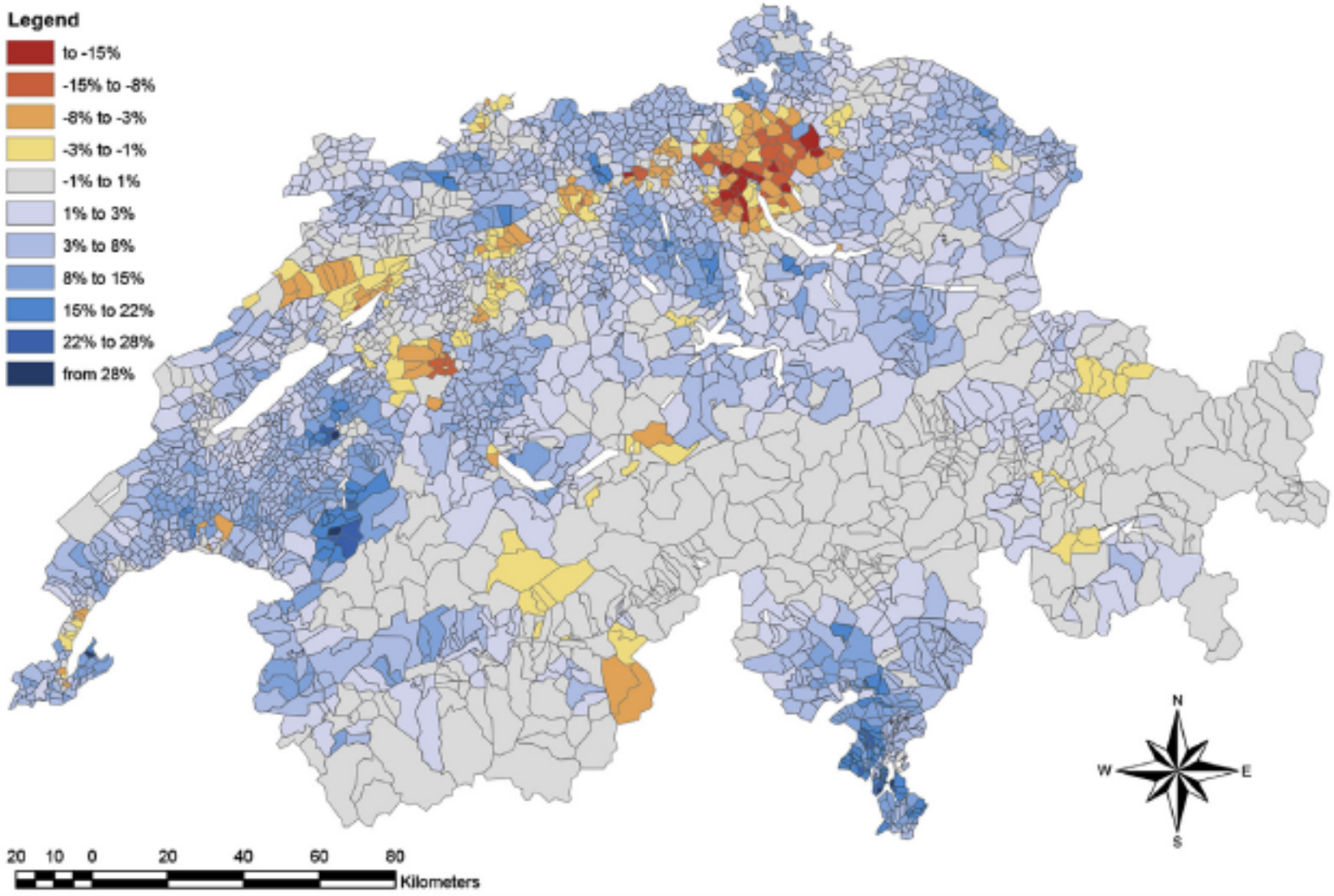
Accessibility	Share of mobiles	0.61
	Number of trips	0.44
	Trips per hour	0.24
	Out-of-home time	0.10
	Total distance travelled	1.14
Transport price index	Share of mobiles	-0.06
	Number of trips	-0.19
	Trips per hour	-1.66
	Out-of-home time	-1.95
	Total distance travelled	-0.84

Source: Weis und Axhausen (2013)

2010 Switzerland general accessibility

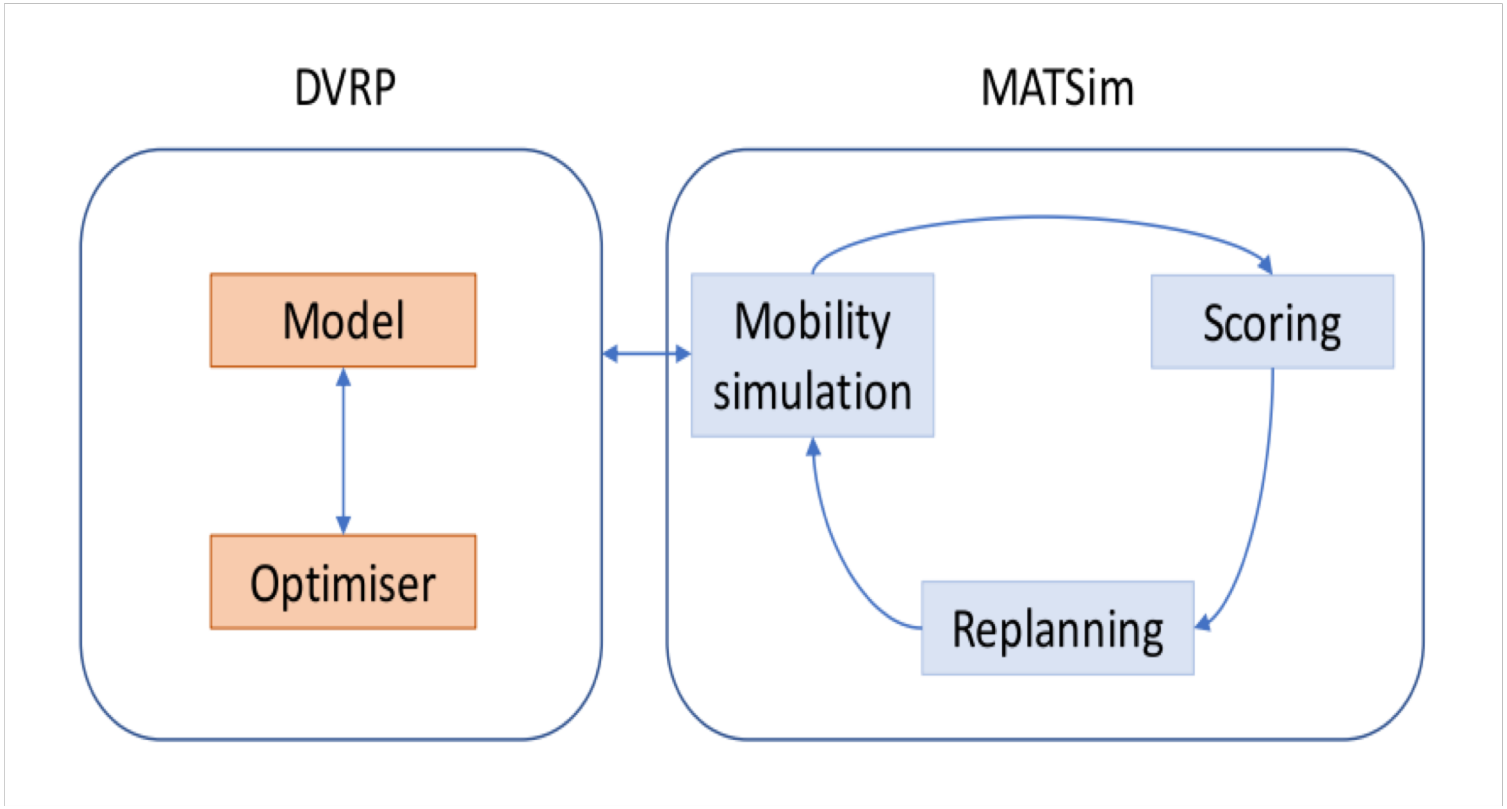


Accessibility change for scenario 3/c with induced demand



MATSim: An open-source agent based simulation

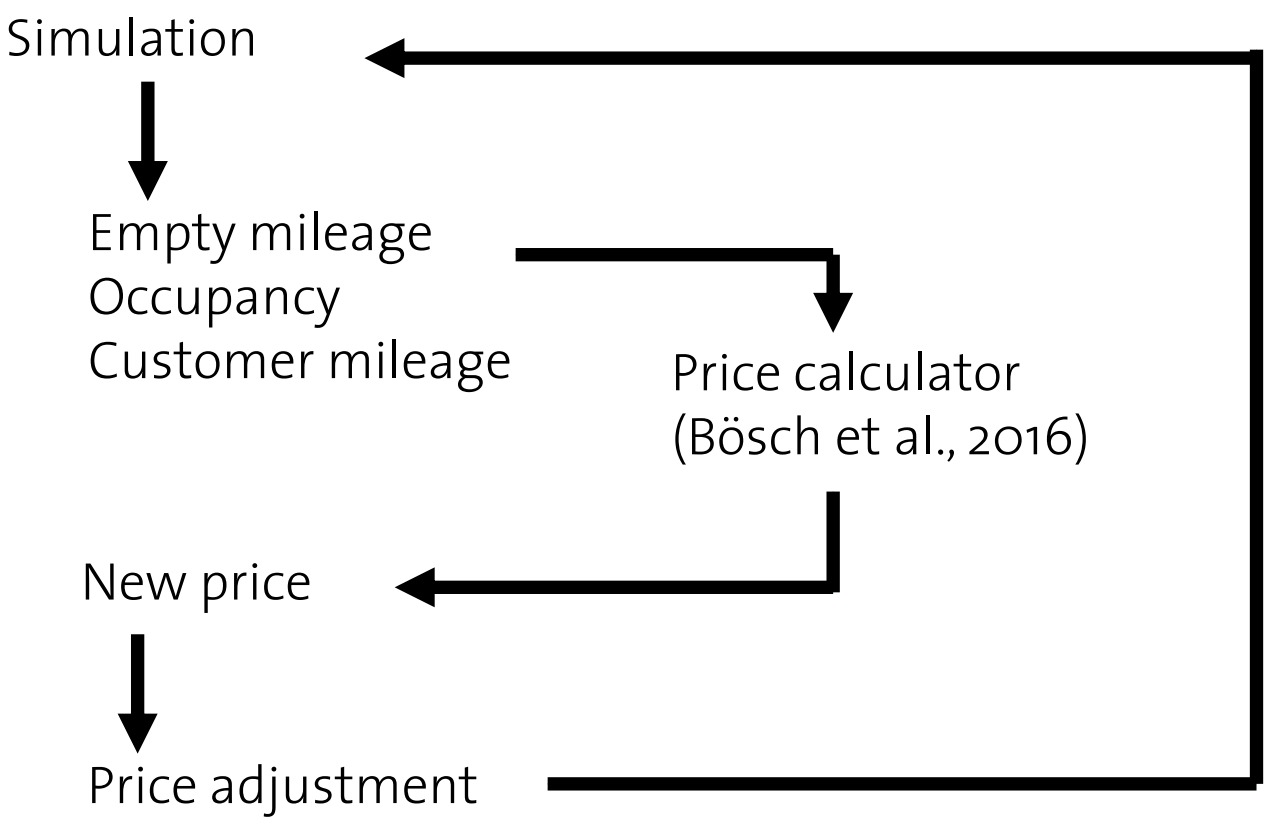
Simulation Framework: DVRP extension



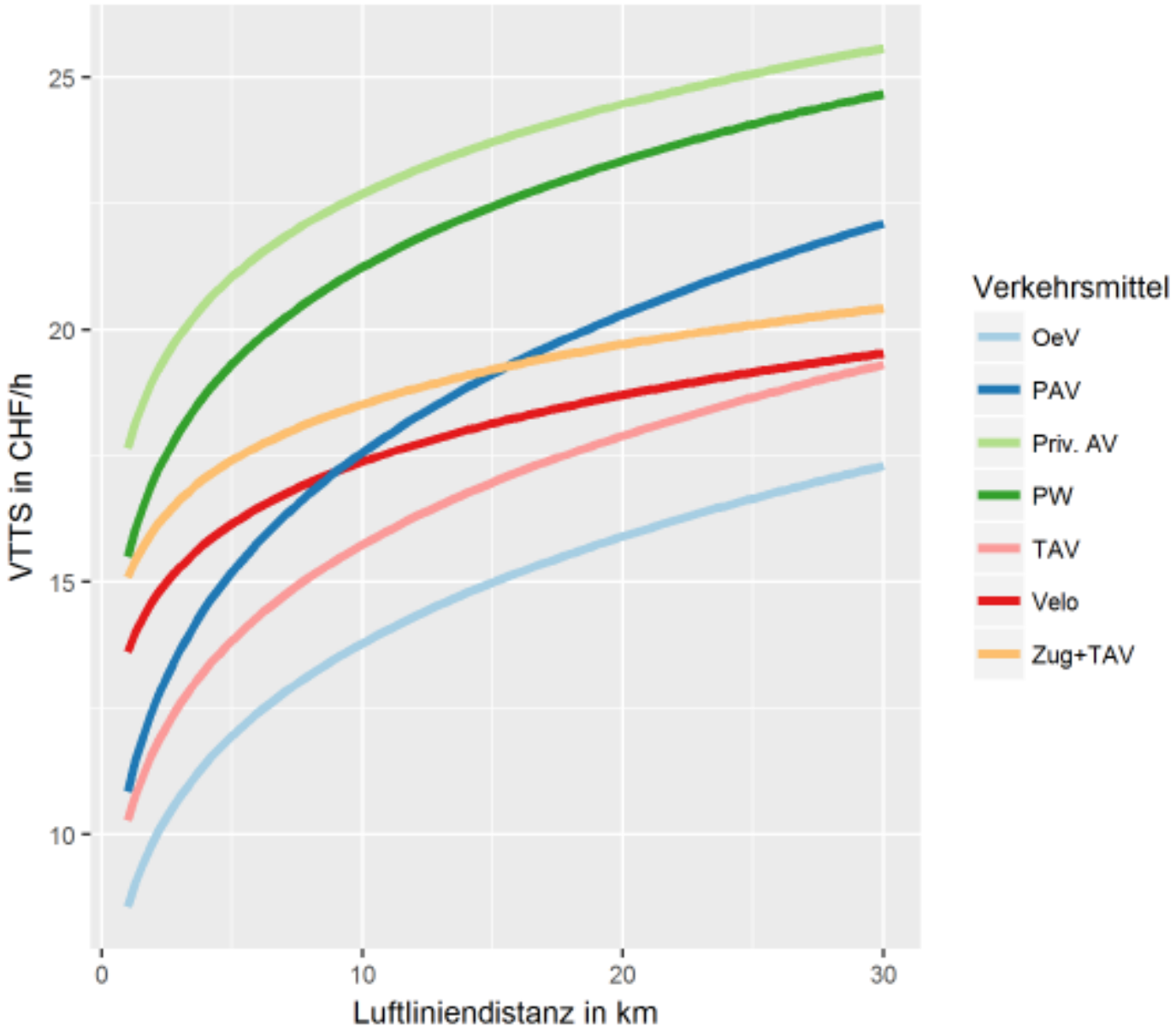
Maciejewski et al. (2017)

Zürich AV scenarios

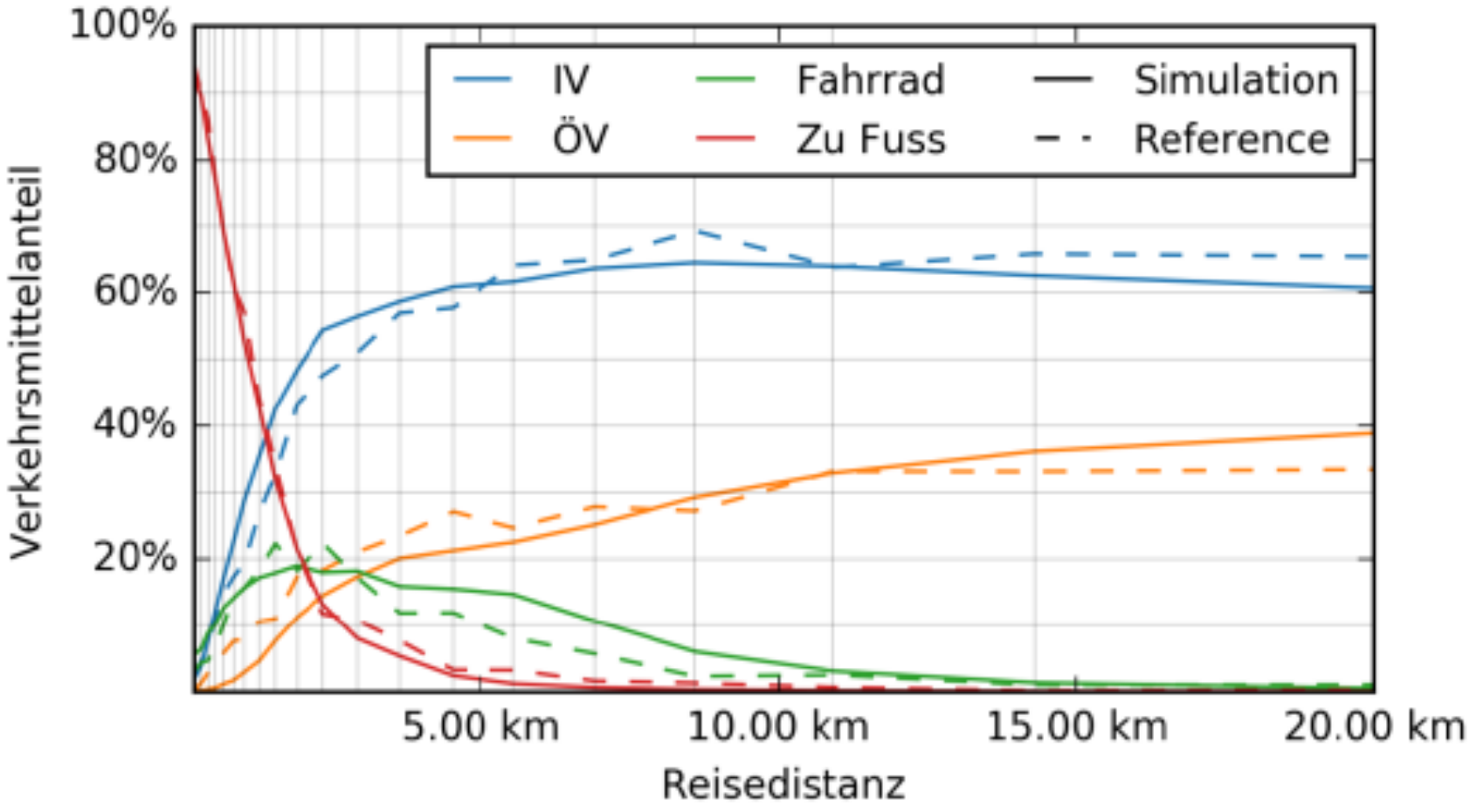
aTaxi price and fleet size determination



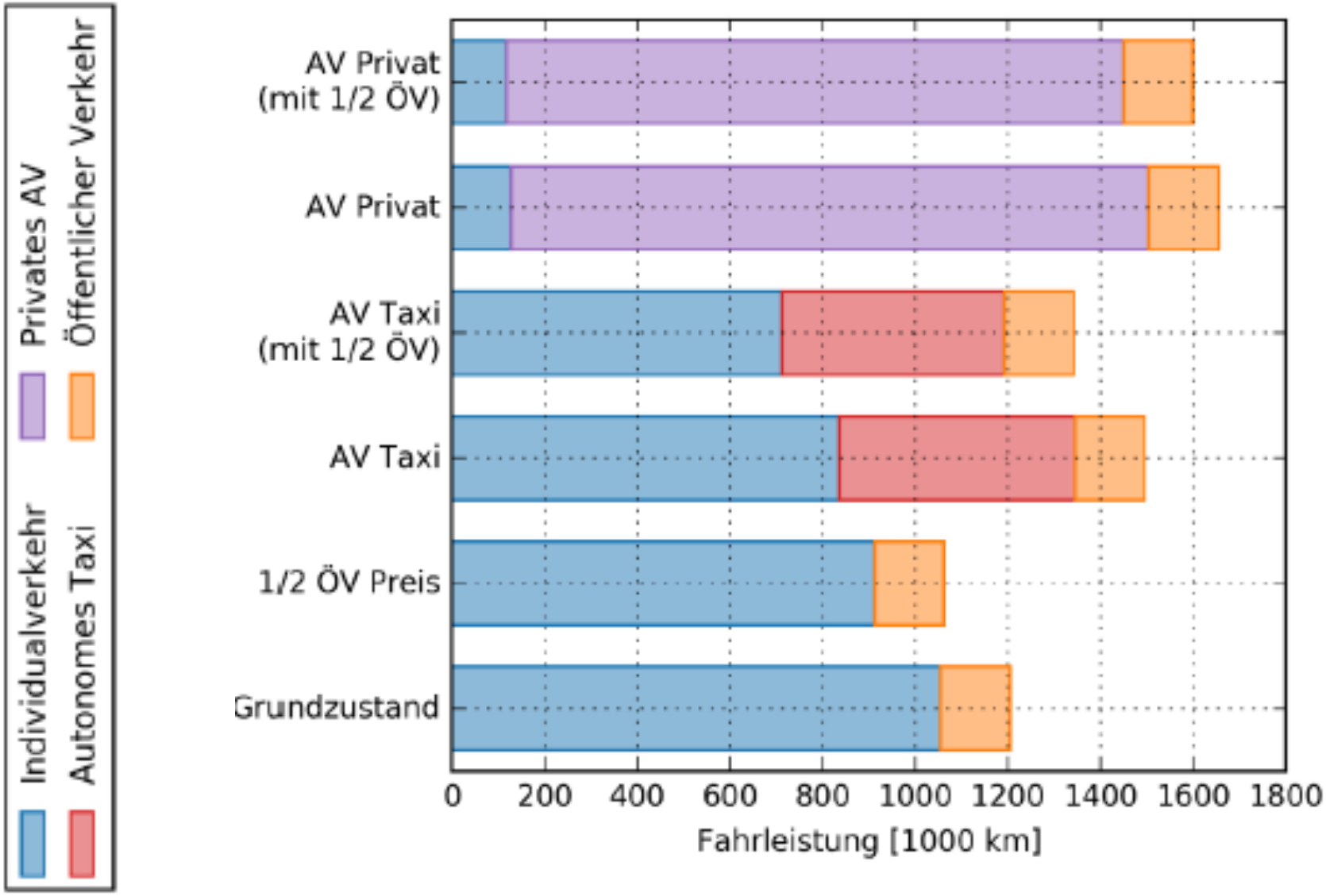
VOT by mode from a three phase SC experiment



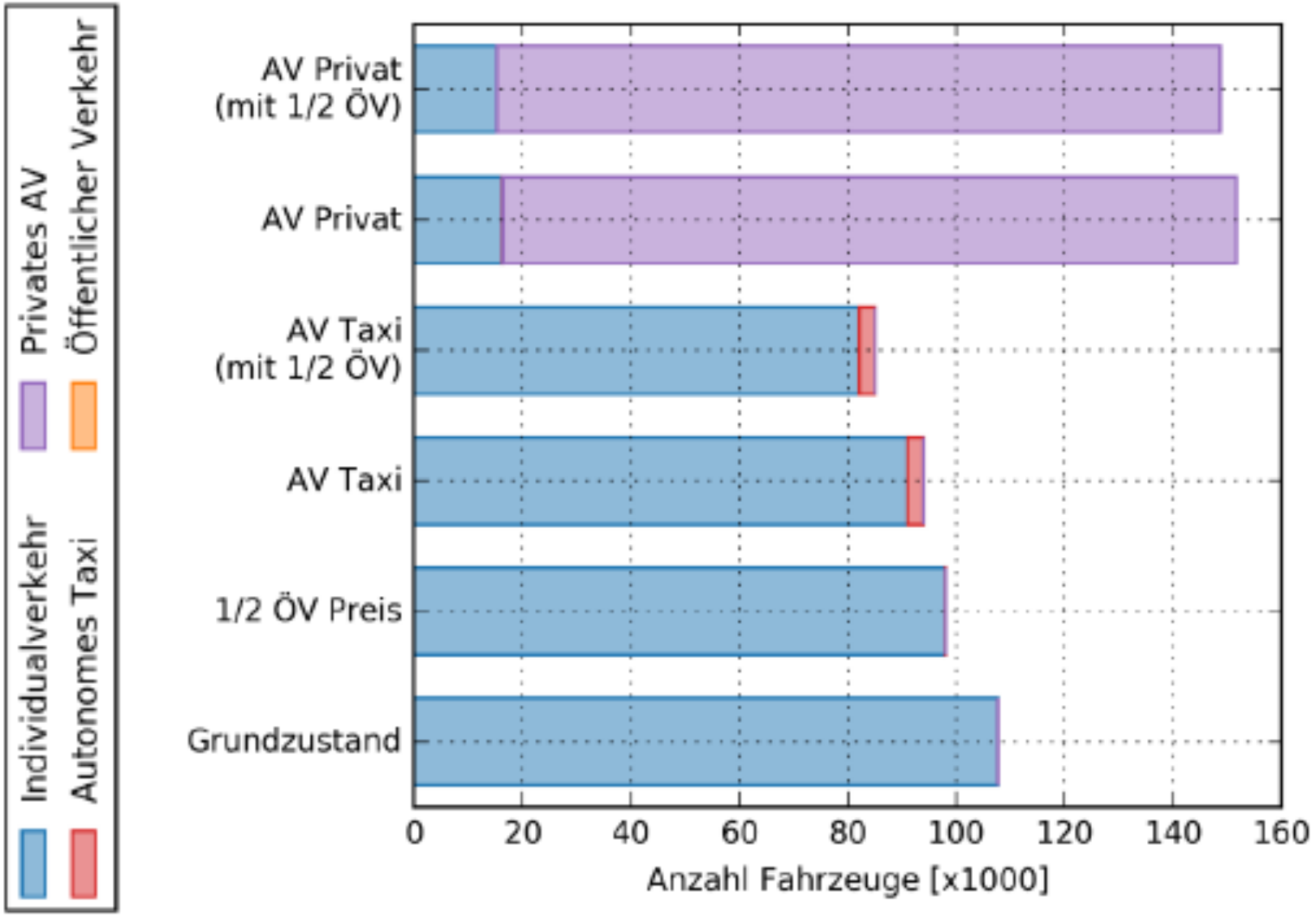
Calibration of the base scenario: Mode by distance



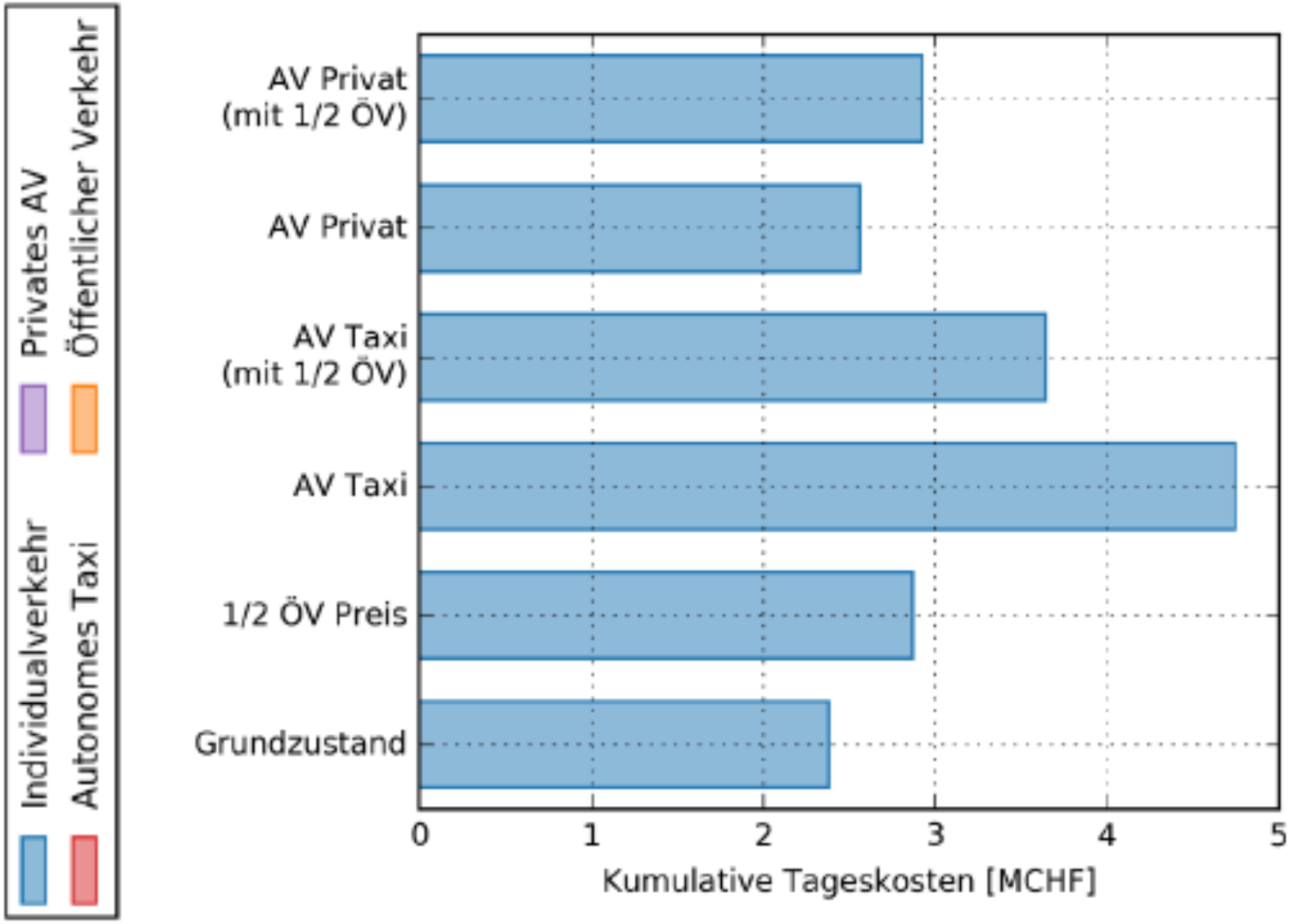
Scenario results – city only: VKT



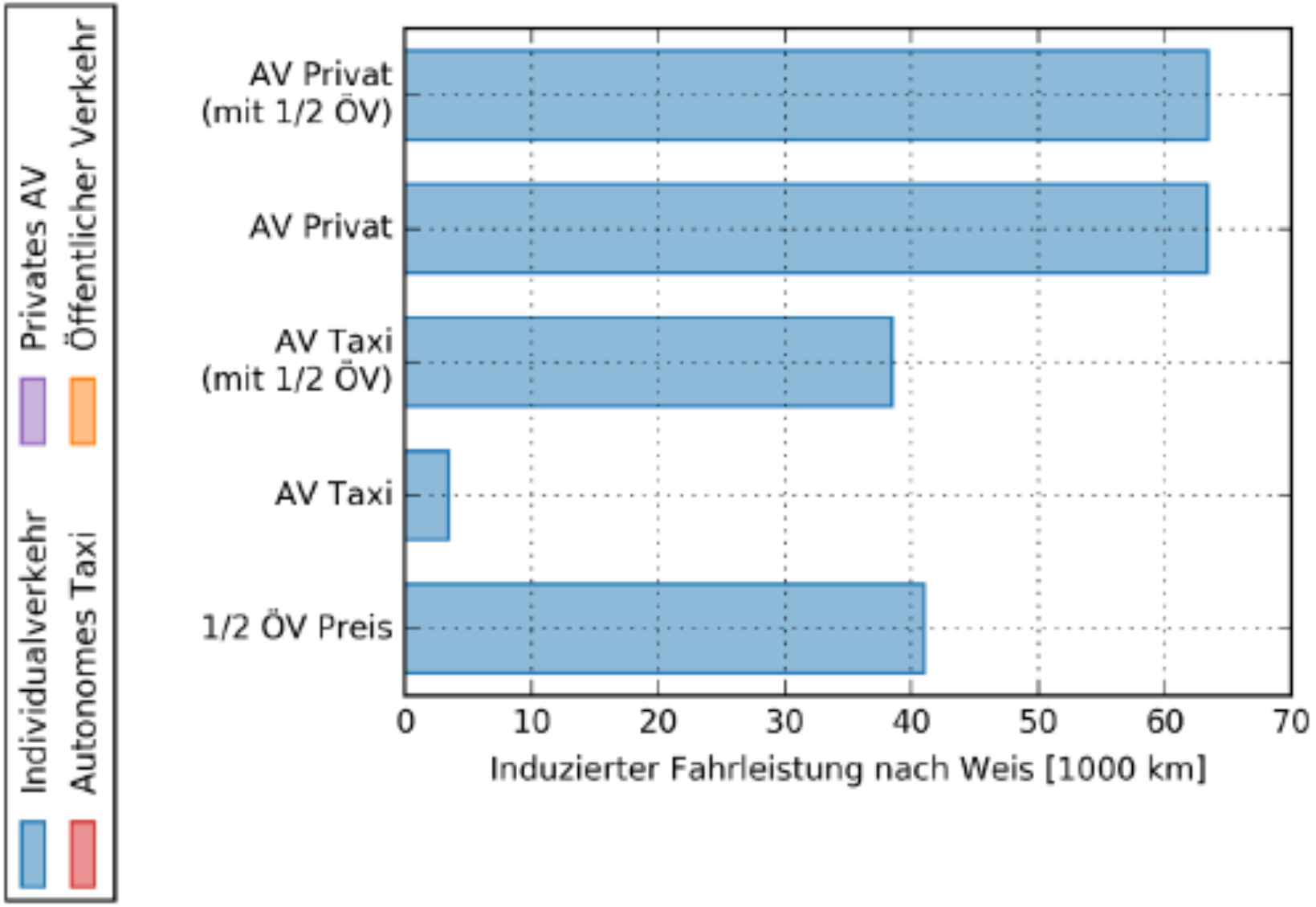
Scenario results - city only: Number of vehicles



Results city only: Costs per day



Results city only: Induced VKT

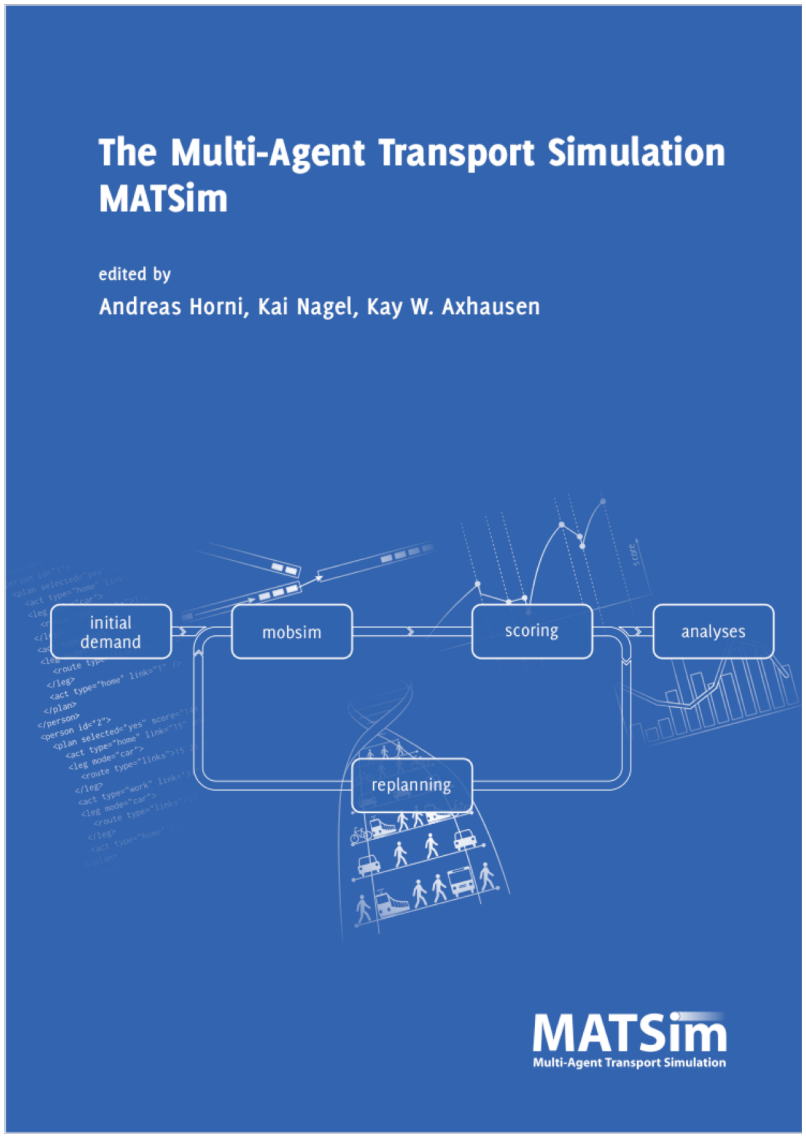


What should we do next?

Next steps

- More work on acceptance of AV
  - By age and education
  - By location of residence
- More work on future cost/prices by type of operator
- More work on the efficiency of the fleets (empty kilometres, parking, drop off/pick up, rebalancing, dispatch)
- More work on how to achieve system optimum with fleet operators
- More work on future ‘public transport’ ?

Questions ?


The Multi-Agent Transport Simulation
MATSim
edited by
Andreas Horni, Kai Nagel, Kay W. Axhausen
initial demand
mobsim
scoring
analyses
replanning
MATSim
Multi-Agent Transport Simulation

Questions ?

See also

www.ivt.ethz.ch

http://www.ivt.ethz.ch/forschung/autonomes-fahren.html

Further references

Hörl, S. (2016) Implementation of an autonomous taxi service in a multi-modal traffic simulation using MATSim. Master Thesis, Chalmers University of Technology, Göteborg.

Maciejewski, M., J. Bischoff, S. Hörl and K. Nagel (2017) Towards a testbed for dynamic vehicle routing algorithms, Accepted for presentation at the *15th International Conference on Practical Applications of Agents and Multi-Agent Systems*, Porto.

Bischoff, J., M. Maciejewski (2017) Simulation of City-wide Replacement of Private Cars with Autonomous Taxis in Berlin. *Procedia Computer Science*, **88**, 237-244.