Preferred citation style

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Chances and impacts of autonomous vehicles

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S Hörl for the work on AV simulation

P Bösch, F Becker and H Becker for the cost estimates

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

Basic assumption 1

Accessibility ~

Opportunities,

Speeds

Basic assumptions2

Traffic is a system of moving, self-organising

Queues

Basic assumption 3

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

number of *slots*

for the desired speed and the

current demand

Basic assumption 4

Travel demand (pkm) is a

normal good

i.e. it grows with

sinking "generalised costs"

Basic assumption 5

The travellers chose their

average generalised costs

with their package of

locations (residence, work) and mobility tools

Basic assumption 6

A person‘s travel demand is the

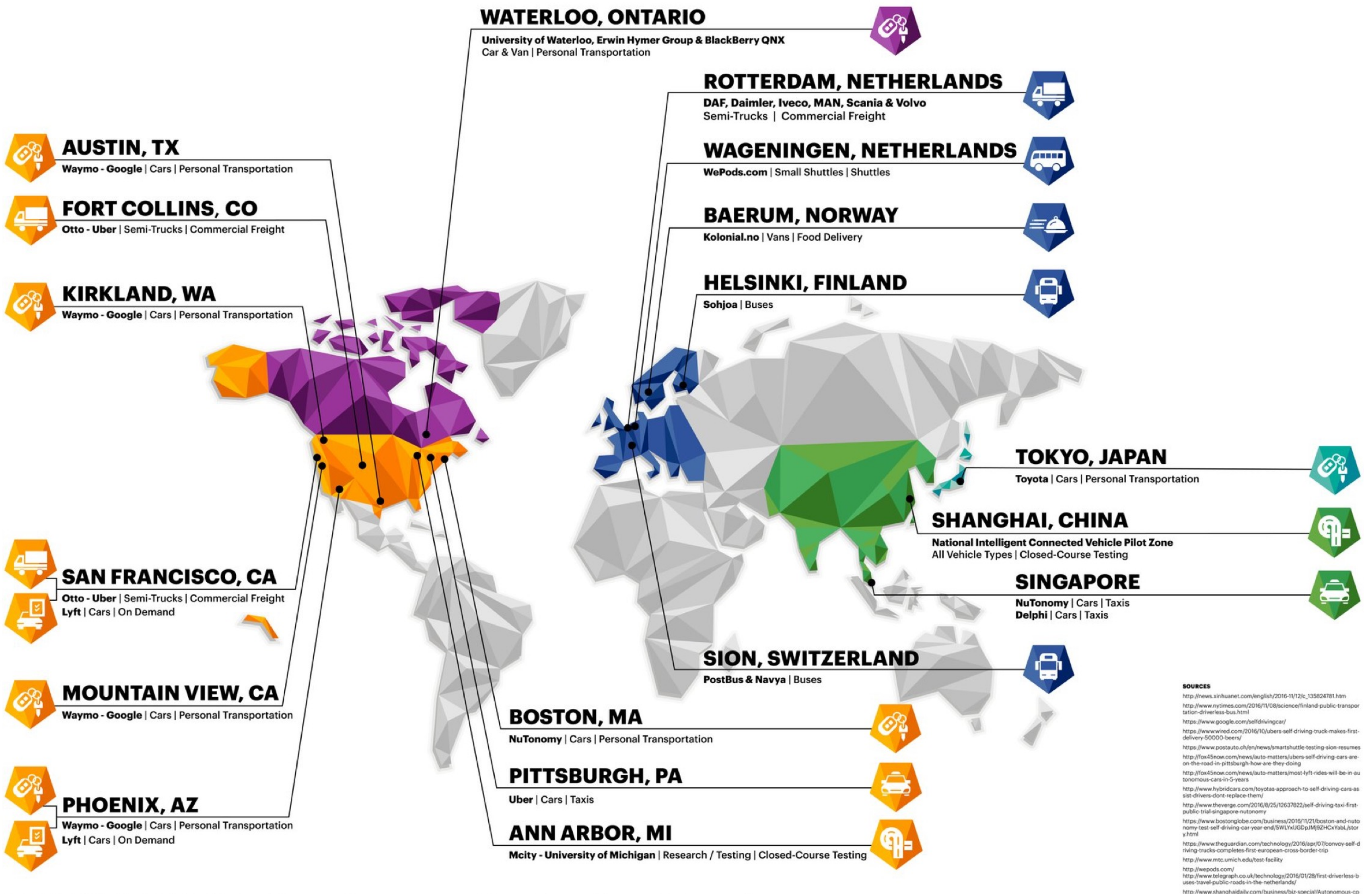
result of its activity participation

constrained by the currently

available time and money resources

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

What are the current expectations?

What are the current expectations?

- AV will reduce the generalised costs (time perception, 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

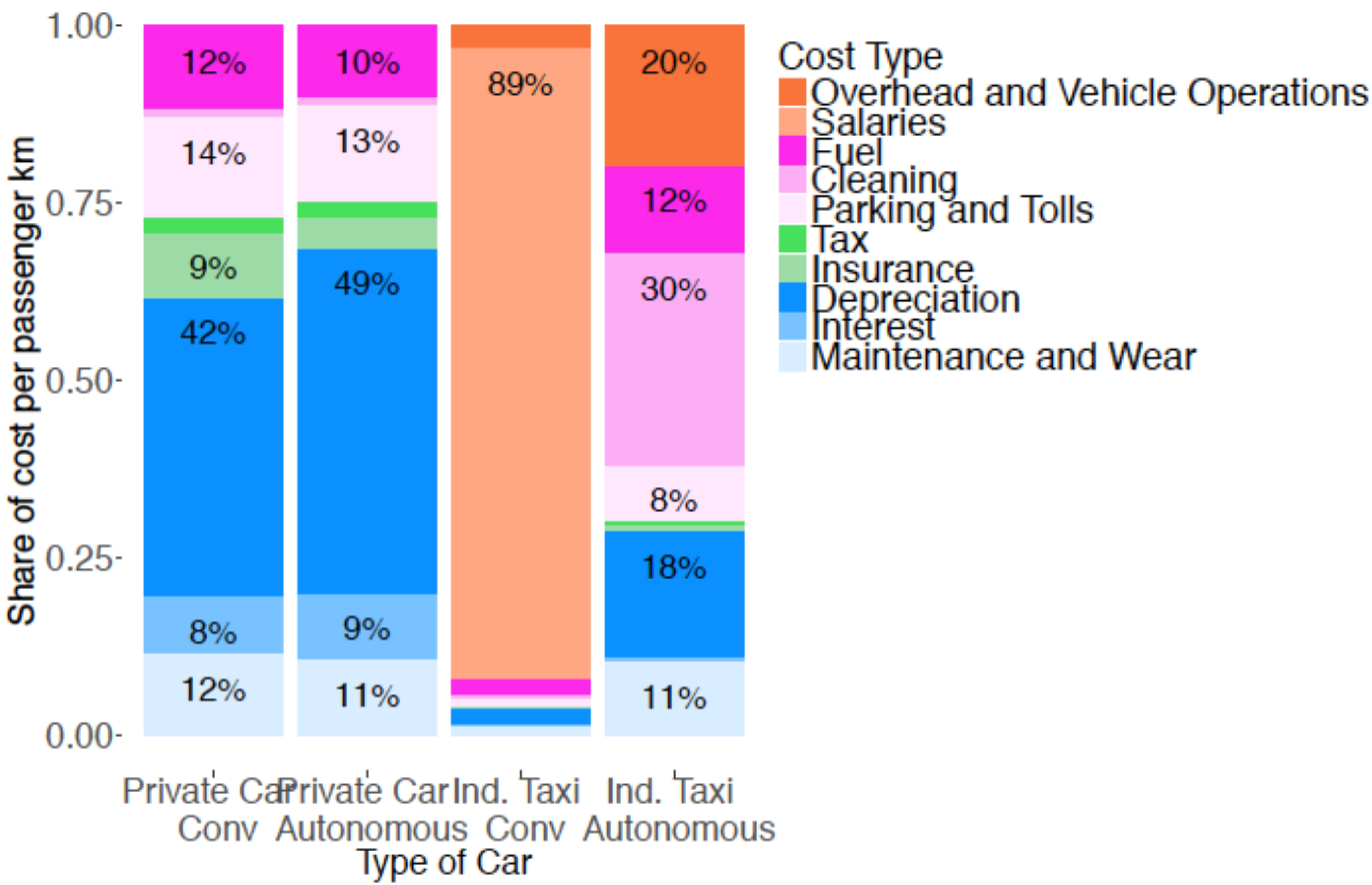
Basic trade-offs

Basic trade-offs between supply and demand

- Costs for generalised cost (service) levels
  - Fixed costs
    - Ownership, taxes, insurance, repair
    - Management
  - Variable costs
    - Fuel, toll, parking, maintenance, cleaning
    - Promotion

- Generalised costs
  - Access/egress walk and waiting time
  - Speed (urban, longer-distance trips)
  - Quality of the ride (design, cleanliness, in-vehicle services)
  - Fares (pricing models)

Updated full cost/pkm estimate (current occupancy levels)



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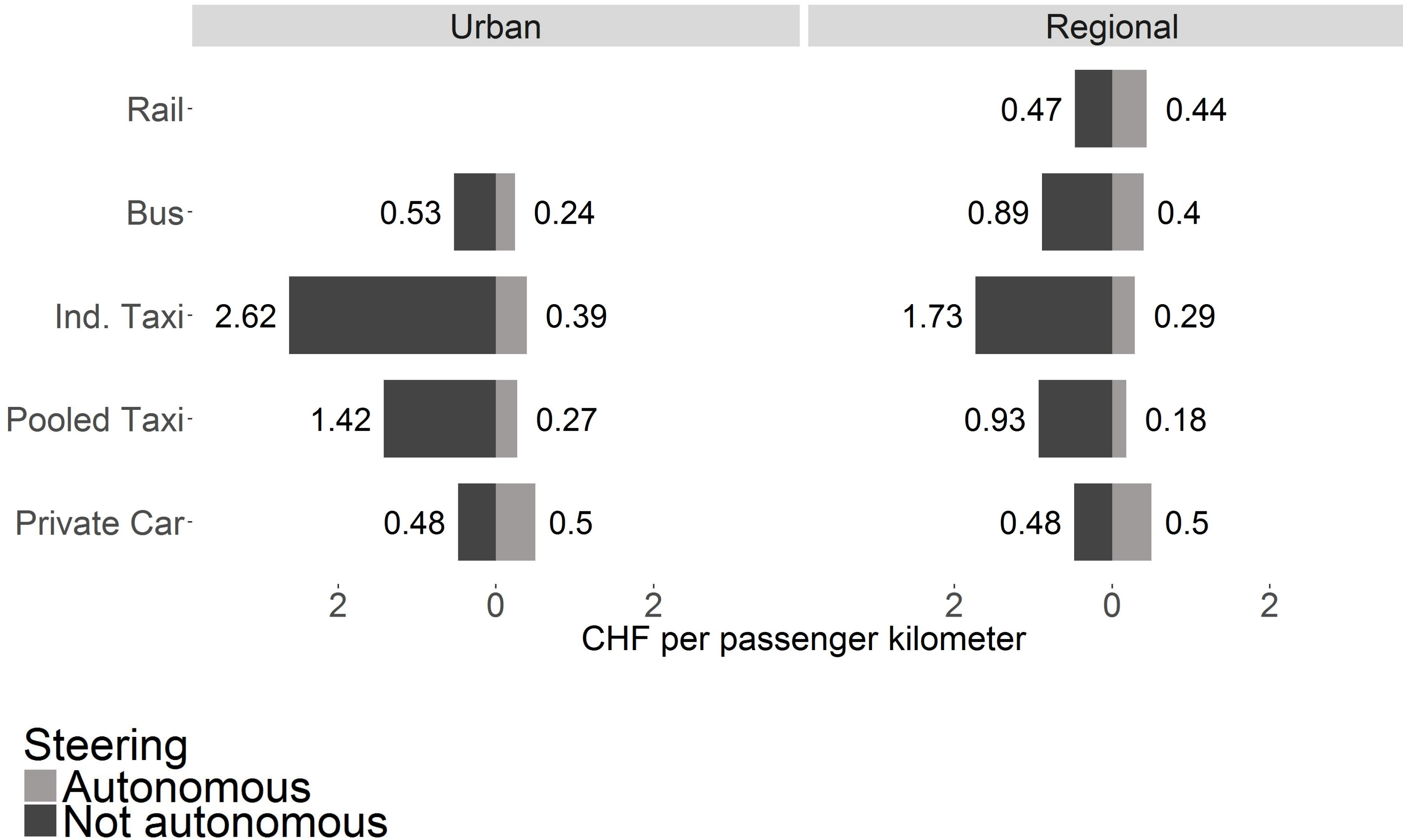
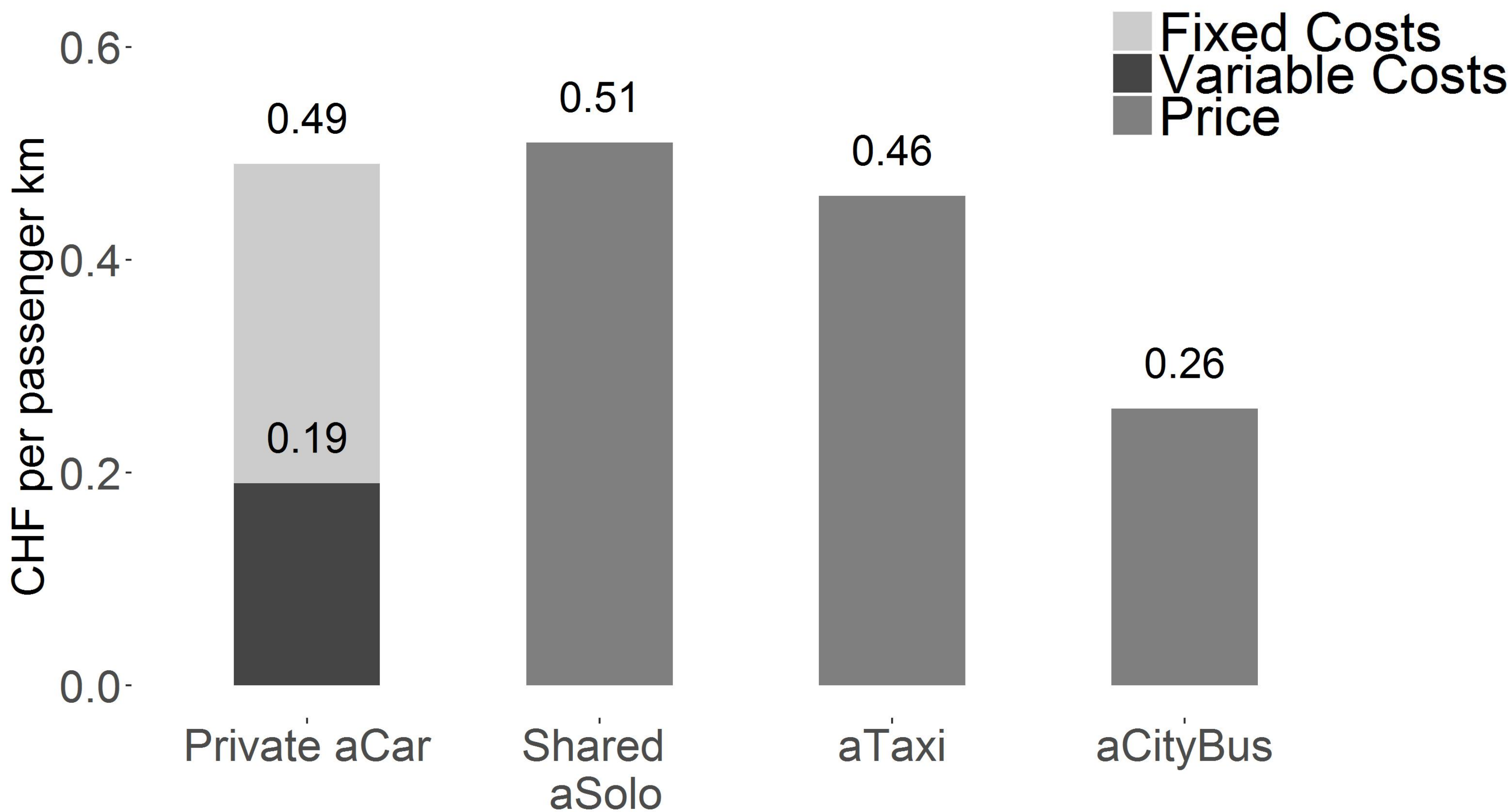


Updated full cost/pkm estimate (current occupancy levels)



Some scenarios for a 2030 Level 5 vehicle future

Facets

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

Scenario 1: As before

- Dispersed: Current owners replace their vehicles
- Transit 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
- Transit 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 MVV expands into small vehicles
- Larger vehicles and hub-operations are encouraged
- System optimum routes are allocated over the days
- MVV 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

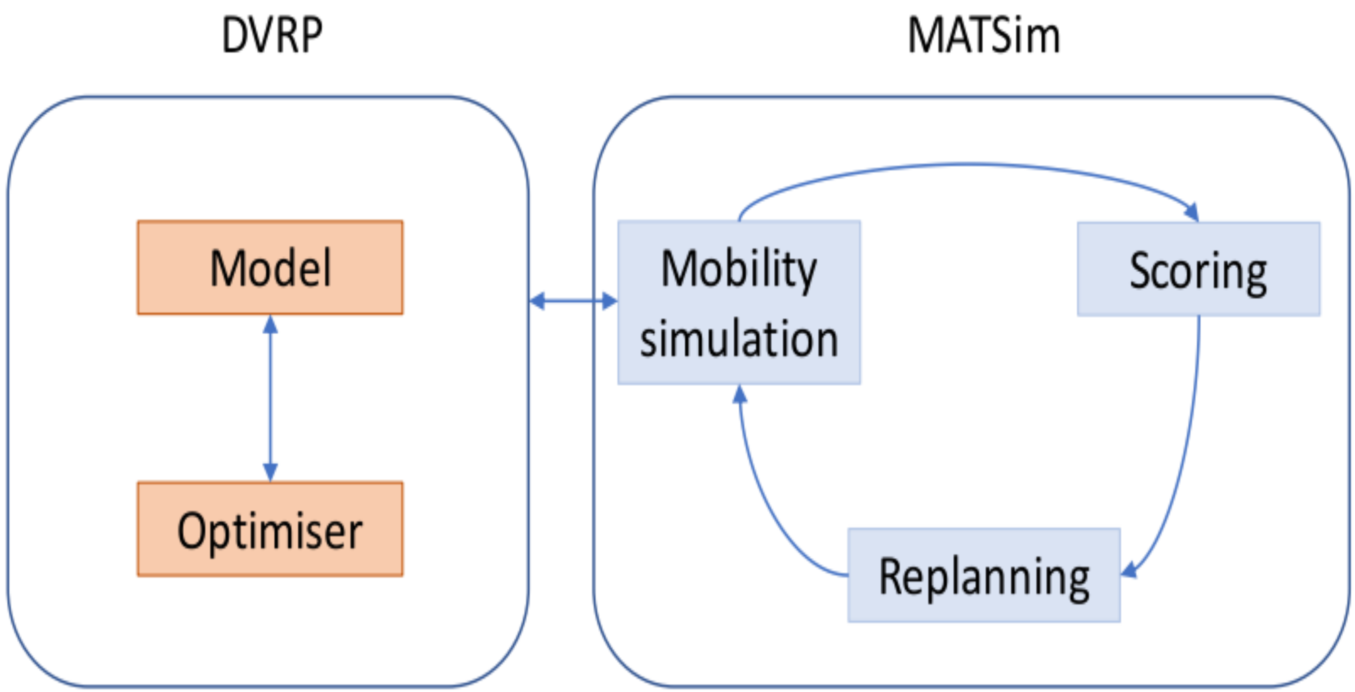
How to enable the mobility of low income travellers?

- Today
  - Public covers the fixed costs, especially for railways, but also 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, where each kilometre is tracked and chargeable
  - Income-adjusted rebates ?
  - Income and work-distance adjusted rebates ?
  - Fixed free kilometre budget ?

MATSim: An open-source agent based simulation

Simulation Framework: DVRP extension



Maciejewski et al. (2017)

Simulation Framework: DVRP further extensions

- Single & multi passenger trips
- Demand-responsive simulation
- Multiple operators

- Full integration as ‘public transport’

Excursus: Homophily in shared rides

Zhao, J. (2017) Urban Agenda for AV Deployment shared mobility, human interaction & urban creativity, presentation at *Future Urban Mobility Symposium 2017*, Singapore, July 2017.

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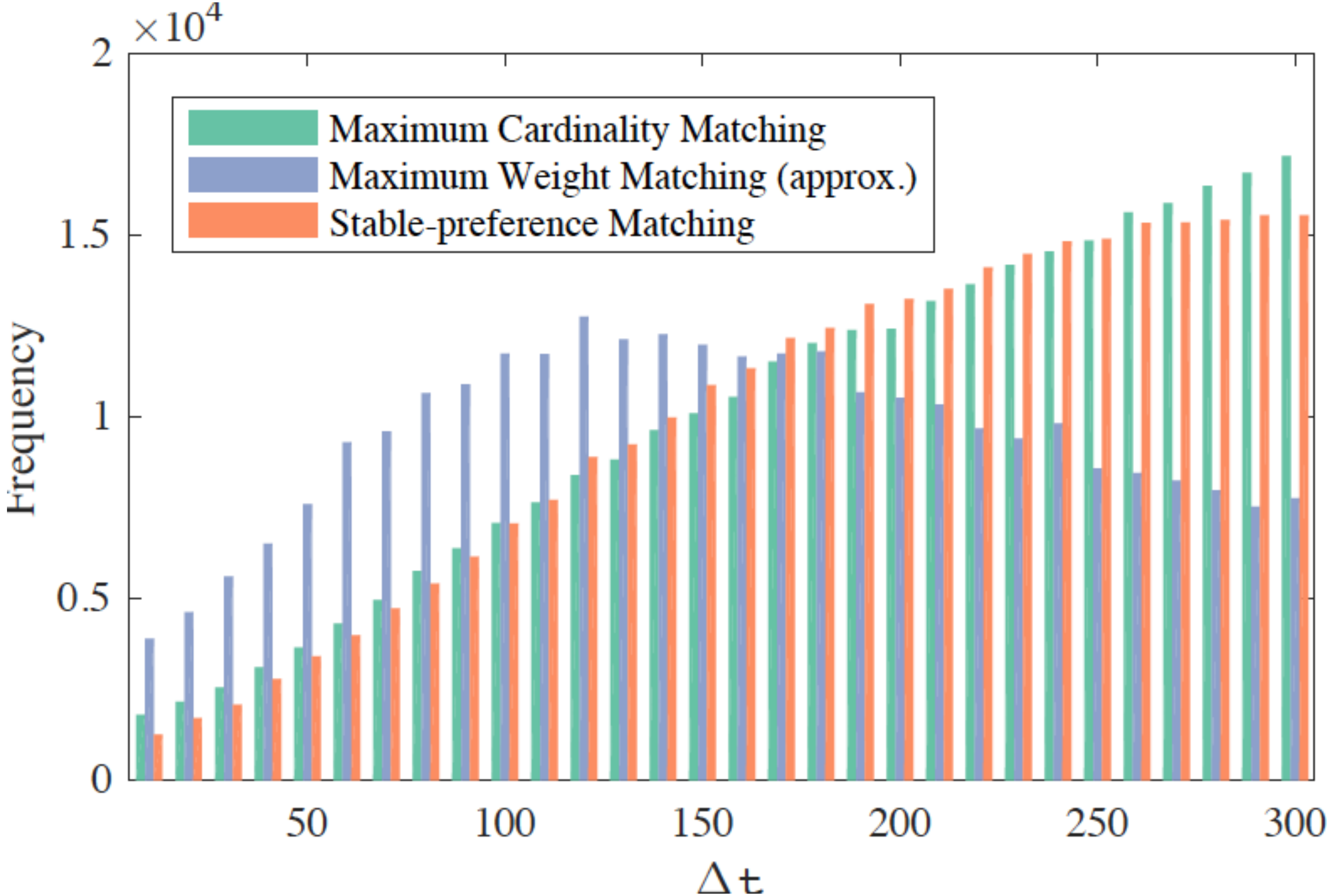
Homophily in shared rides

What would be the generalised costs of matching riders according to their preferred social criteria?

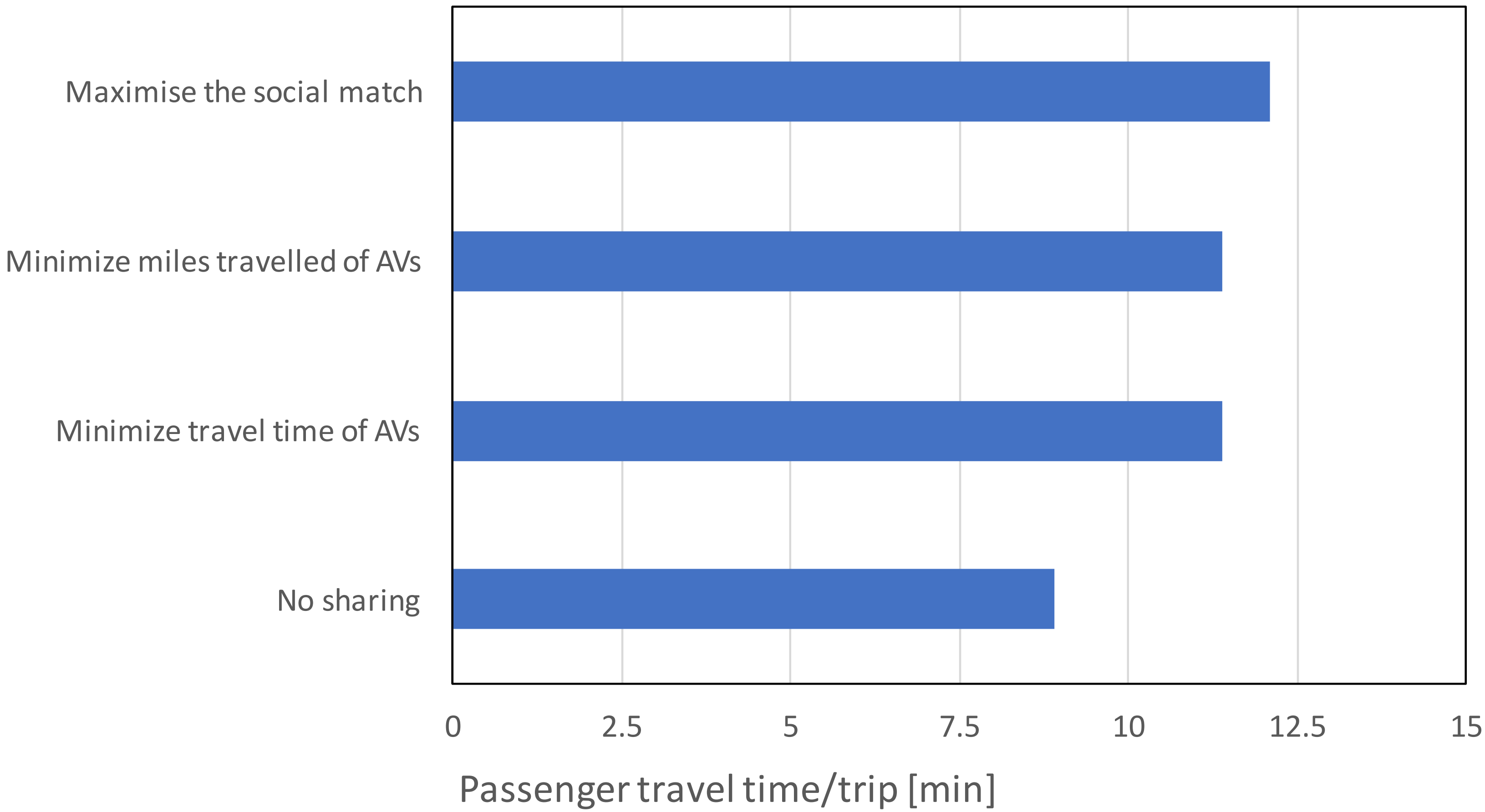
Matching to

- Minimize the travel time of the shared AVs travelling
- Minimize the miles travelled of the shared AVs
- .Maximise the degree of the social match

Number of matches by extra waiting time and criteria



Travel time by matching criterion



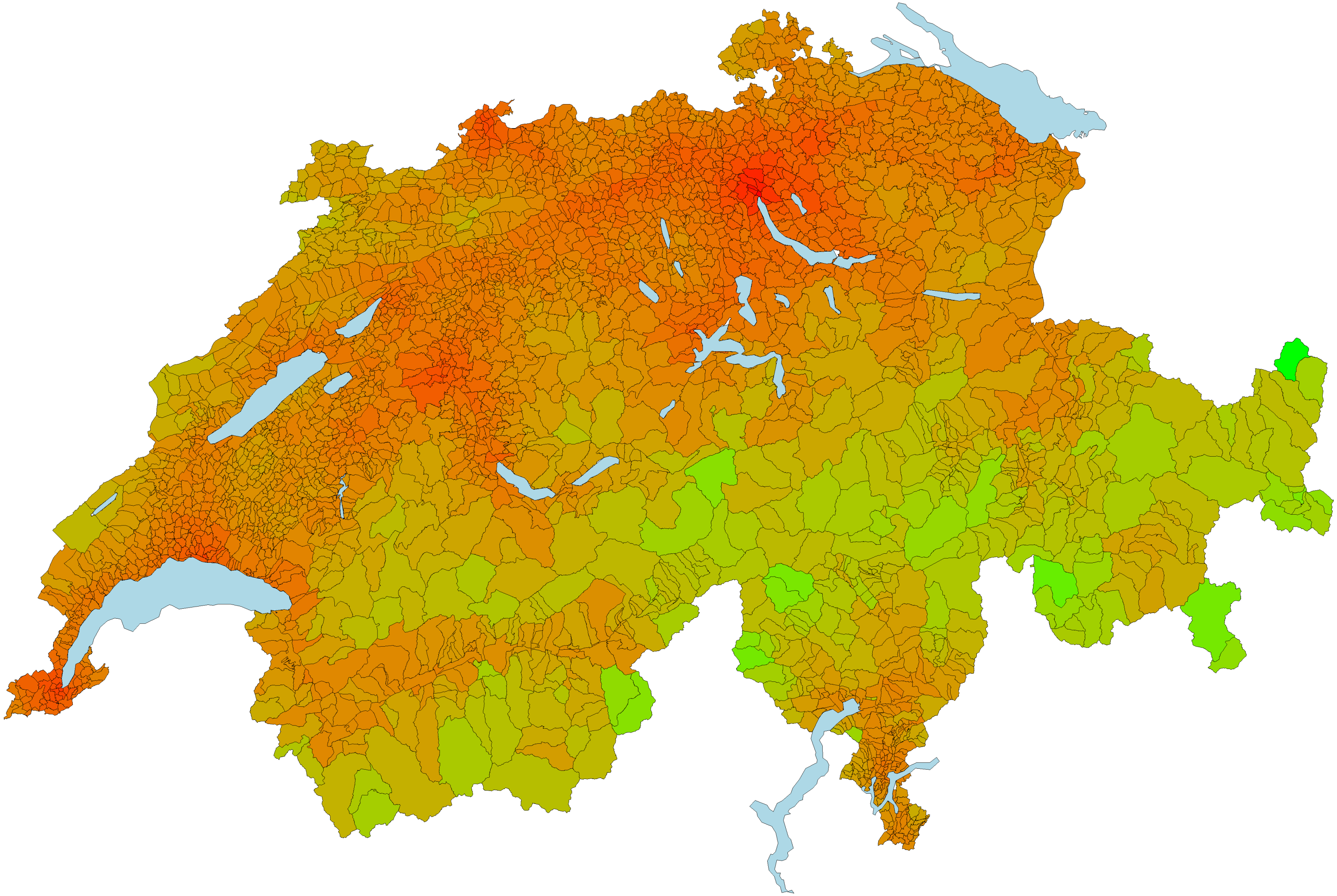
Induced demand by AVs

Induced demand elasticities from a pseudo-panel

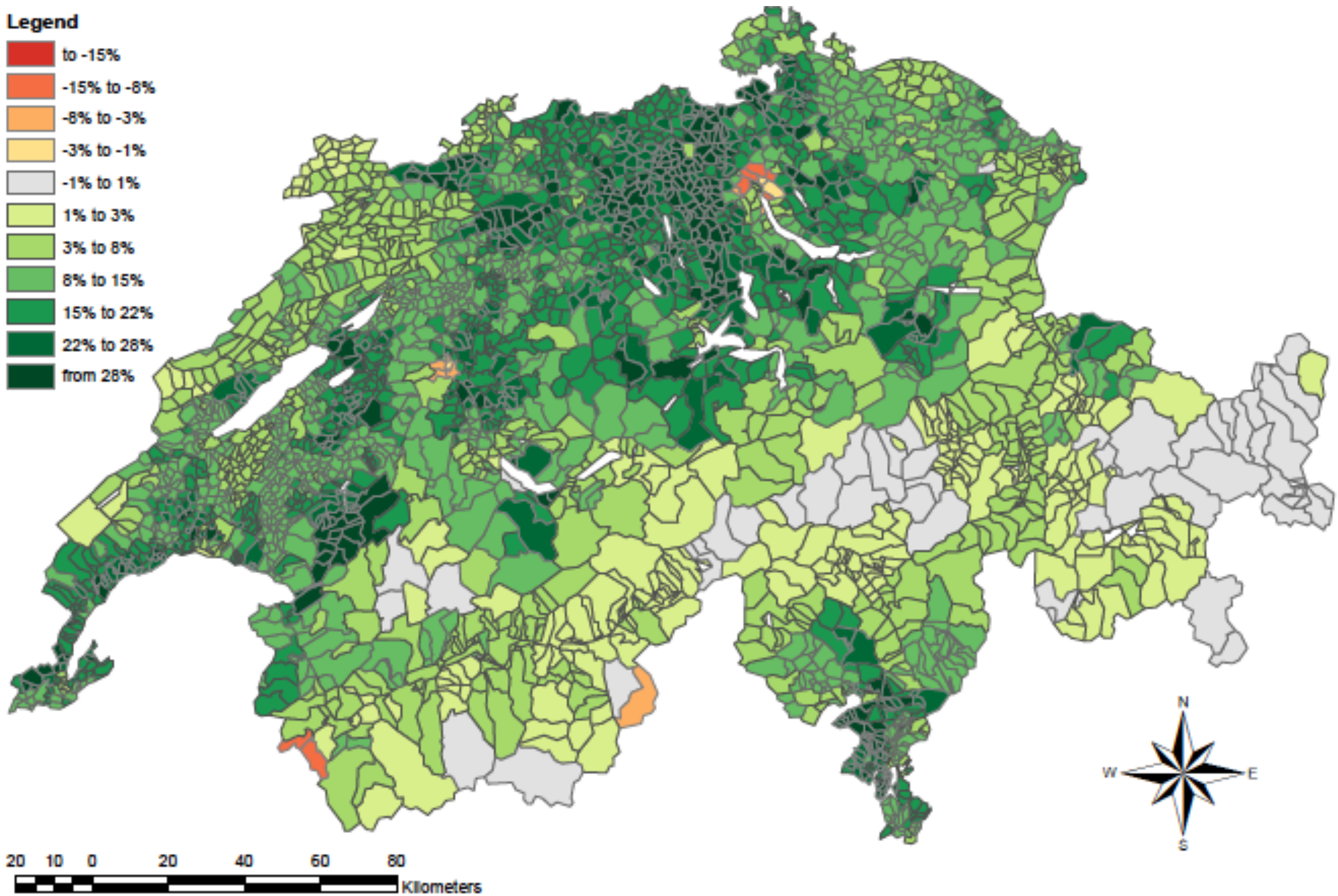
Accessibility	Share of mobiles	0.61
	Number of trips	0.44
	Trips per hour	0.24
	Out-of-home time	0.10
	Total distance travelled	1.14
Transport price index	Share of mobiles	-0.06
	Number of trips	-0.19
	Trips per hour	-1.66
	Out-of-home time	-1.95
	Total distance travelled	-0.84

Source: Weis und Axhausen (2013)

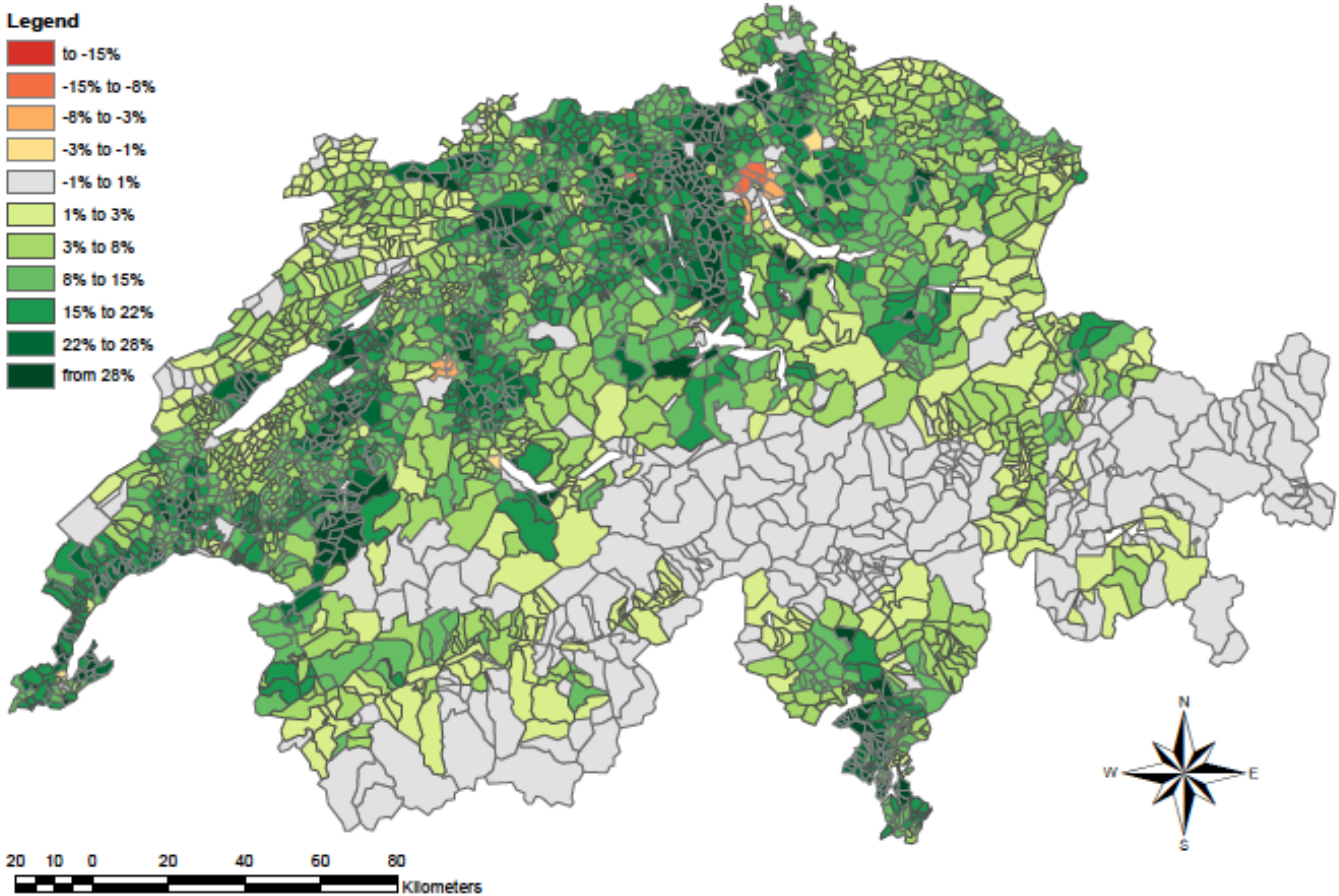
2010 Switzerland general accessibility



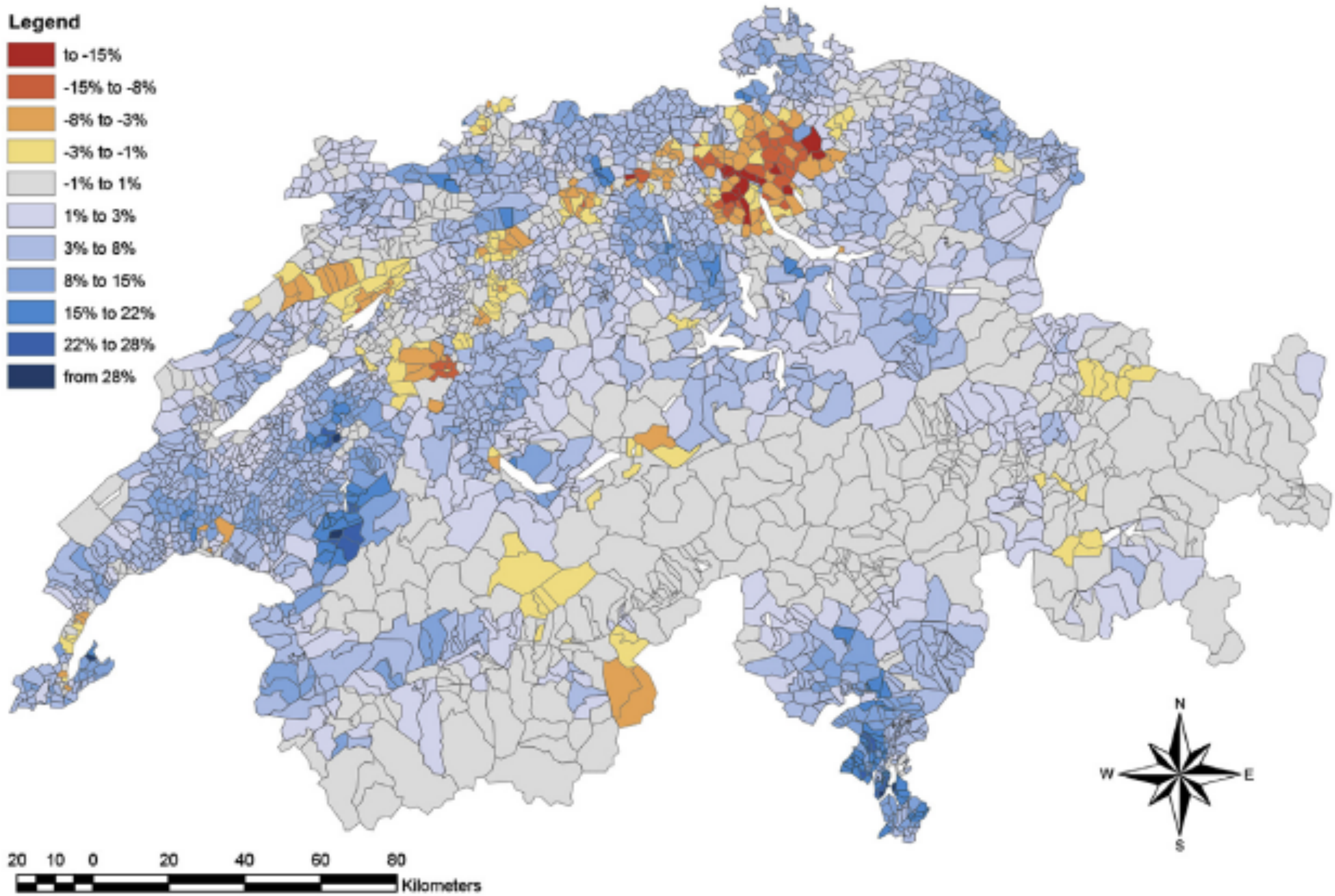
Accessibility change for scenario 3/optimistic



Accessibility change for scenario 3/0 with induced demand



Accessibility change for scenario 3/c with induced demand

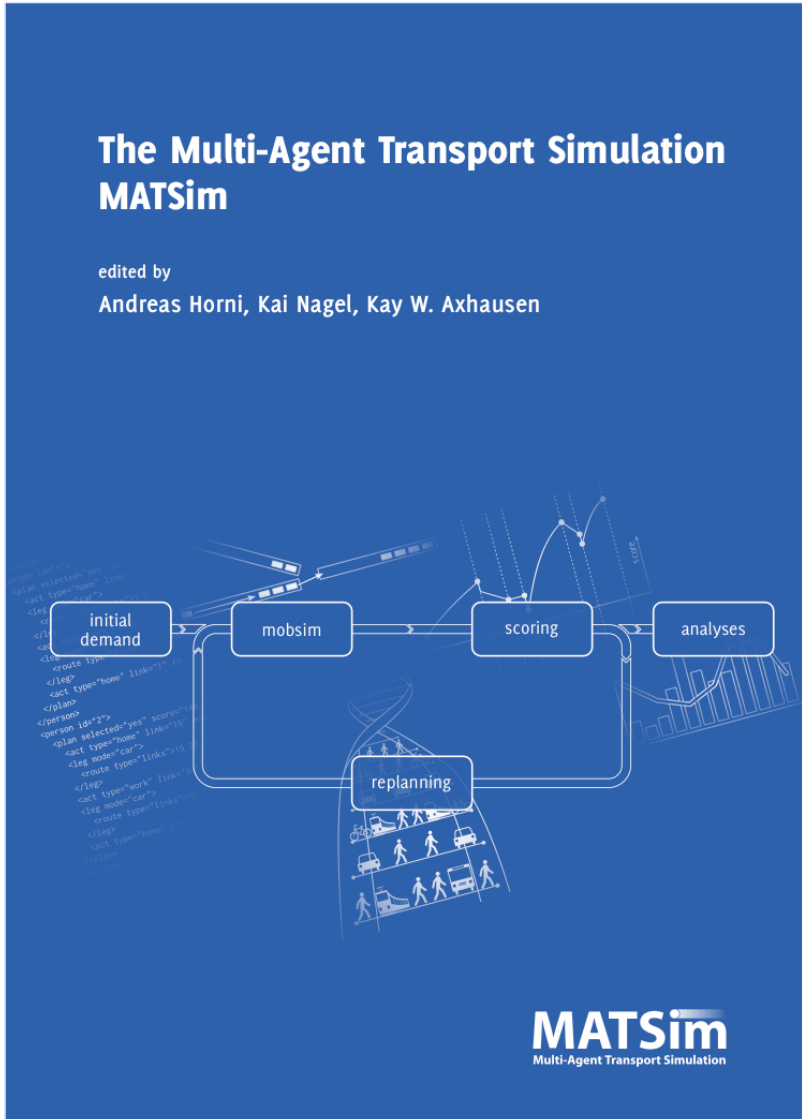


What should we do next?

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 ‘transit’ ?

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

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