Cost-based analysis of autonomous vehicle services

Preferred citation style for this presentation

Becker, Henrik (2017) Cost-based Analysis of Autonomous

Vehicle Services, *KAPSARC workshop on Drivers of Transportation Fuel Demand*, Tysons Corner, VA, April 2017.

Cost-based Analysis
of Autonomous Vehicle Services

Henrik Becker

KAPSARC workshop on
Drivers of Transportation Fuel Demand
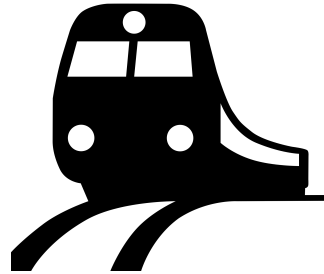
Tysons Corner, VA
April 2017

IVT Institut für Verkehrsplanung und Transportsysteme
Institute for Transport Planning and Systems

ETH

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Mode Choice

(Short-term) mode choice is largely governed by few key factors:

- **Travel time**
- **Cost**
- Reliability / frequency
- Comfort

Autonomous vehicles (AV) change the equation

Travel time

- Compact vehicle design, shorter reaction times
  -> increase highway capacity -> shorter travel time
- More direct connections instead of hub and spoke

Cost

- Sharing and pooling to reduce cost of individual user
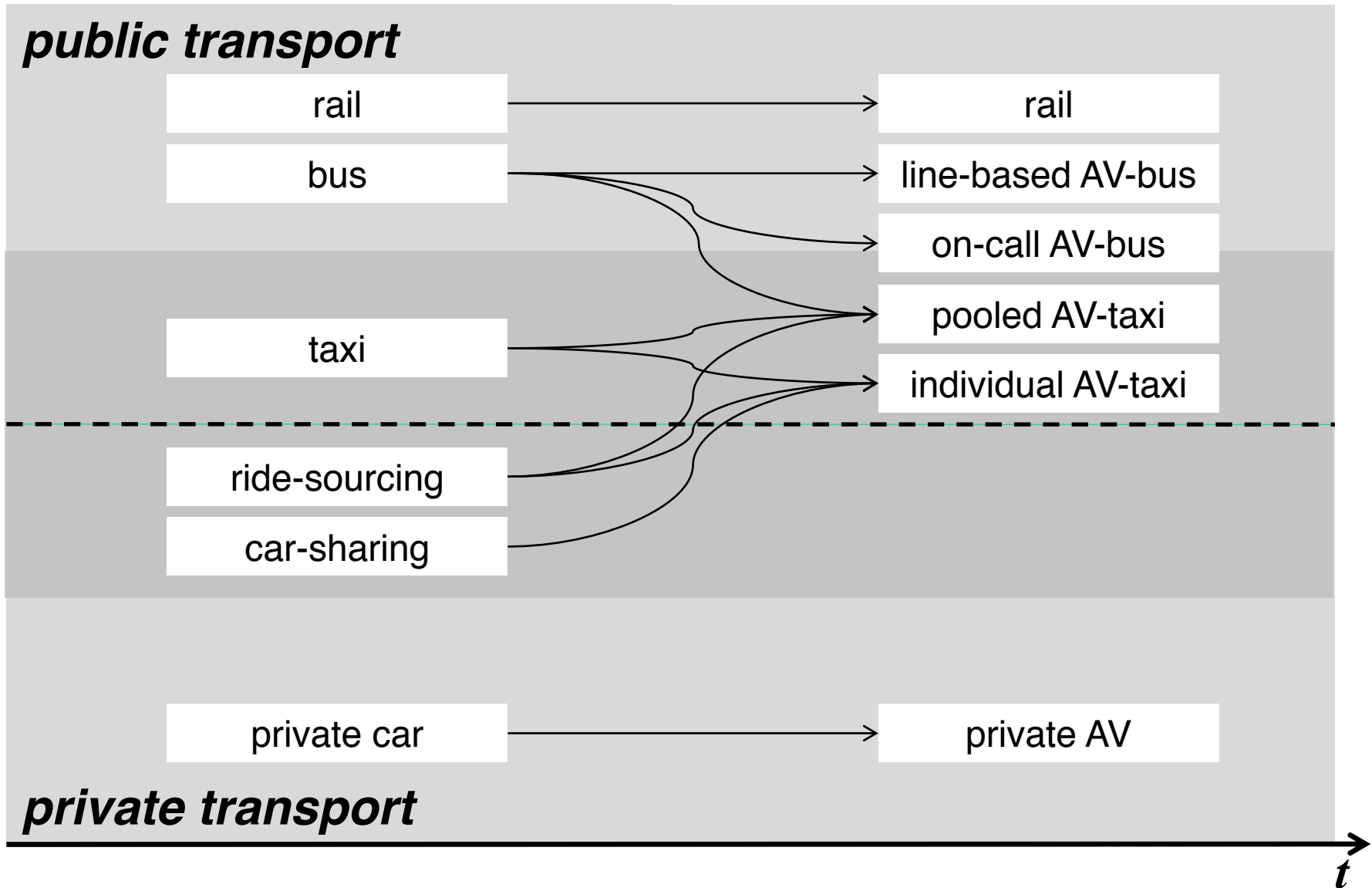- No need to pay for a driver

Reliability / frequency

- Real-time information due to apps

Comfort

- Passenger-oriented vehicle design

AV-technology will reshape almost all modes

... but why can't we use AV-Ubers every situation?

space required
to transport **60 people**

car

bus

bicycle

... there are capacity constraints!

space required to transport 60 people

car · uber · autonomous car

A small experiment

Assume

- all trips (pt + car) are done with an (individual) AV-taxi scheme
- also trips from children and the elderly
- including induced demand
- 15% empty rides
- road capacity increases of 40% within cities and 80%-270% outside of cities
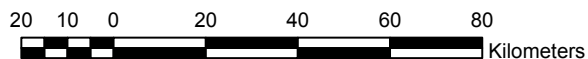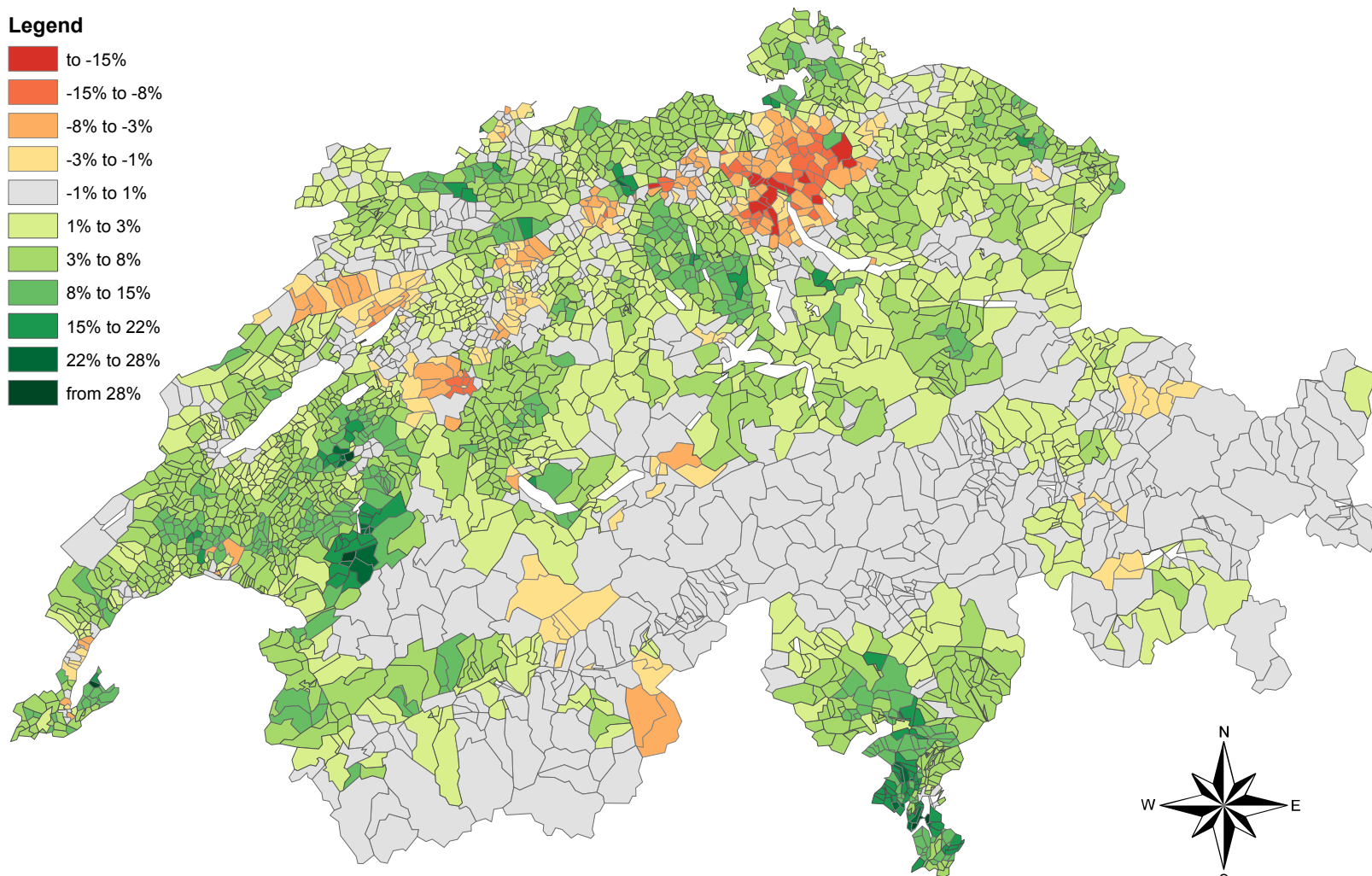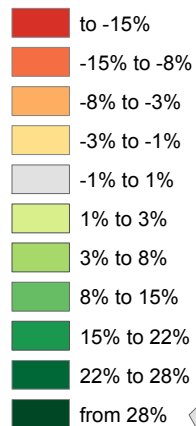
And then: calculate accessibilities for the evening peak hour:

$$A_i = \sum_j w_j e^{\beta c_{ij}}$$

Accessibilities – situation in cities will deteriorate

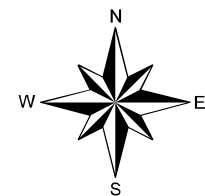**Scenario 3 with Induced Demand
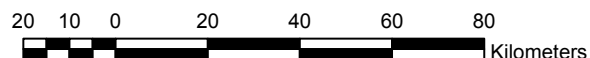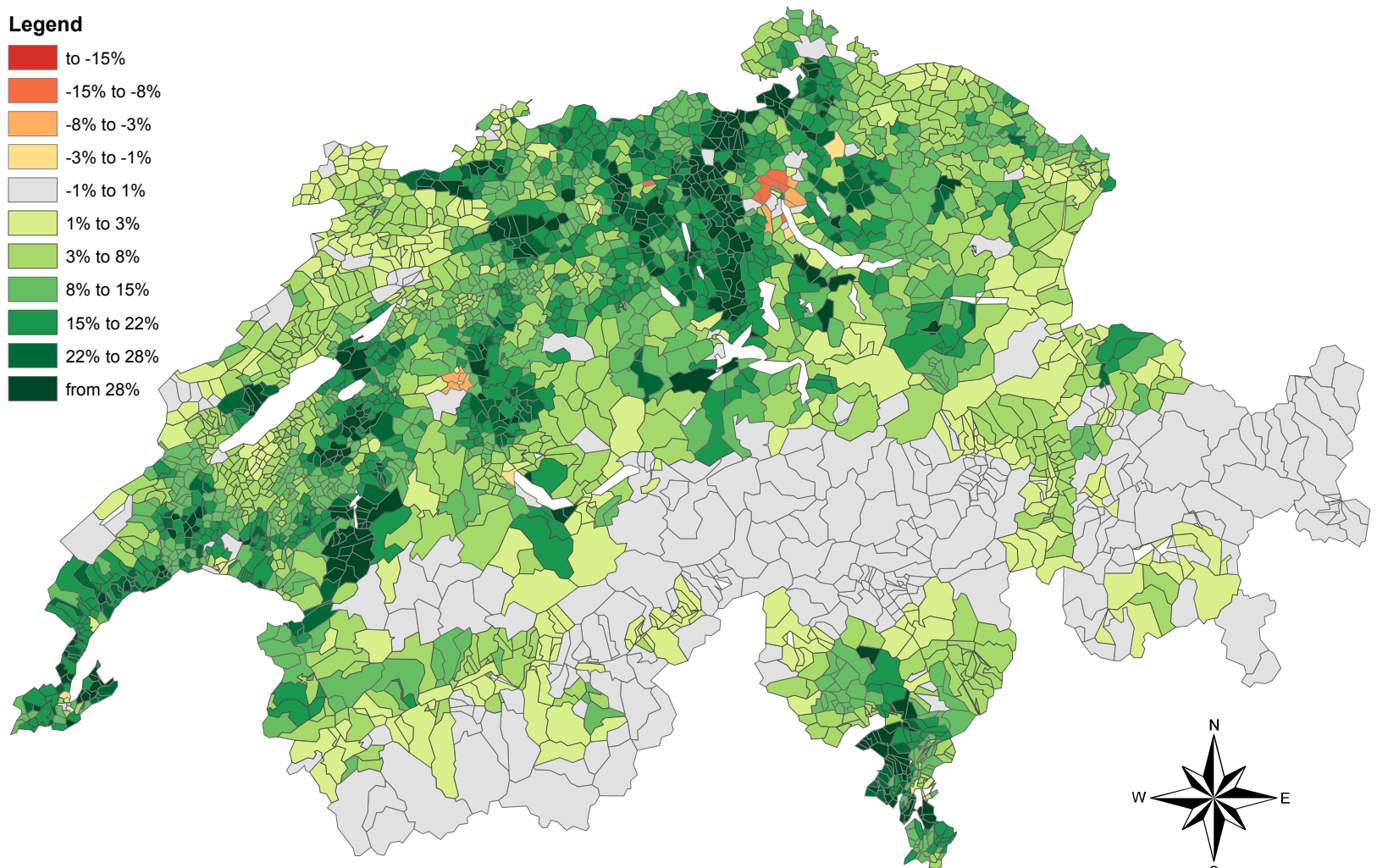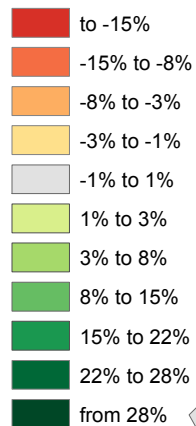Conservative Capacity Increase**

Legend
- to -15%
- -15% to -8%
- -8% to -3%
- -3% to -1%
- -1% to 1%
- 1% to 3%
- 3% to 8%
- 8% to 15%
- 15% to 22%
- 22% to 28%
- from 28%

20 10 0 20 40 60 80
Kilometers

N
W   E
S

Accessibilities – situation in cities will deteriorate

Scenario 3 with Induced Demand
Optimistic Capacity Increase

Legend

- to -15%
- -15% to -8%
- -8% to -3%
- -3% to -1%
- -1% to 1%
- 1% to 3%
- 3% to 8%
- 8% to 15%
- 15% to 22%
- 22% to 28%
- from 28%

20 10 0   20   40   60   80
Kilometers

N
W   E
S

But it is not only a matter of travel time....

… but also a question of the price:

Predicting the operating cost of the new services

1. **Bottom-up determination of vehicle costs**

   - fixed cost (per day)

     (acquisition, insurance, tax, parking, overhead, ...)

   - variable cost (per km)

     (depreciation, maintenance, cleaning, tires, fuel, ...)

2. **Including the effect of vehicle automation and electrification**

   - on the individual cost components

   - based on earlier research and assumptions

3. **Test different parameters for vehicle utilization**
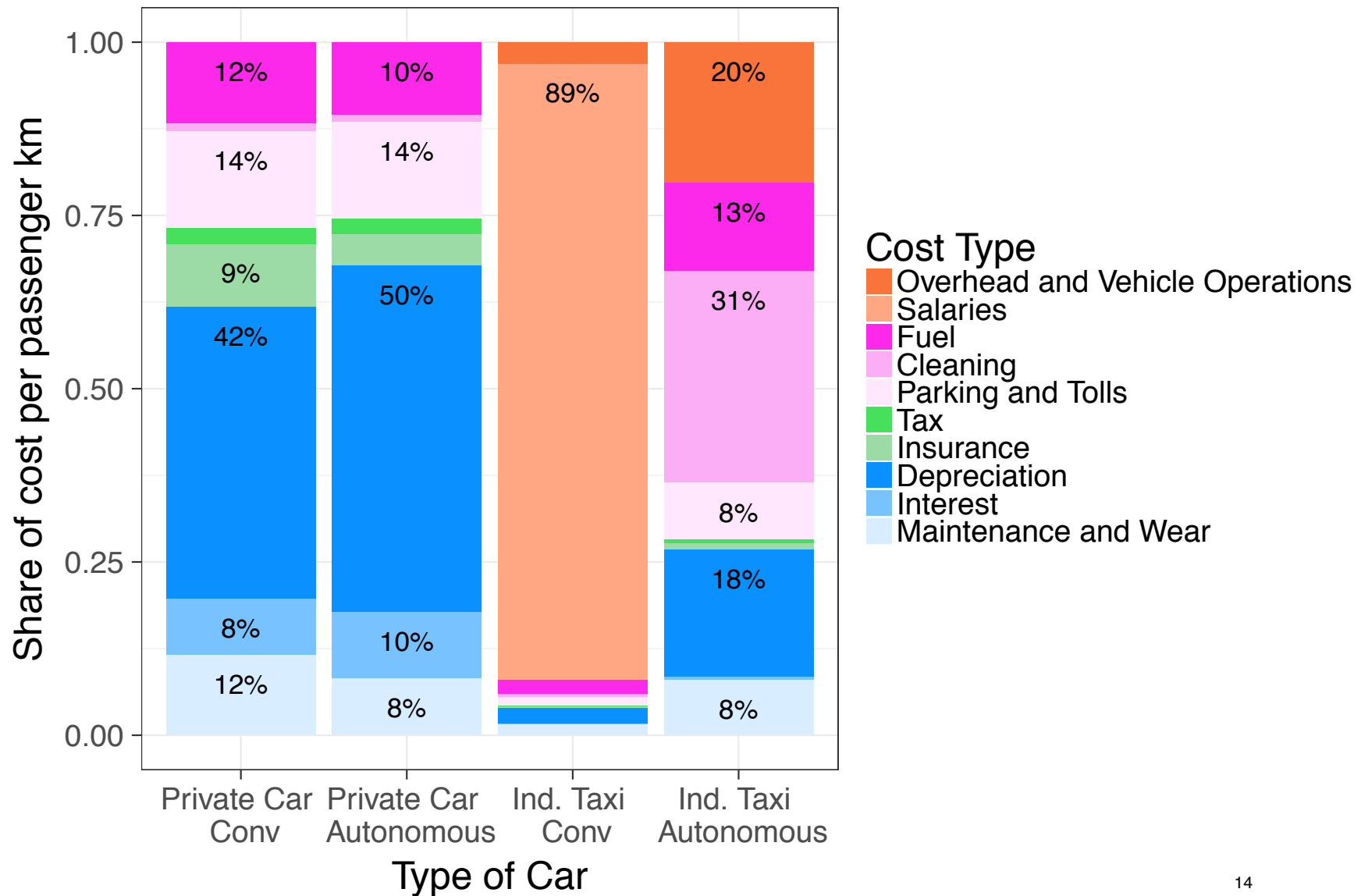
   - based on current bus and taxi operations and
     results from agent-based simulation

     (empty rides, occupancy, active time, kilometers driven, ...)

Considering different vehicle types

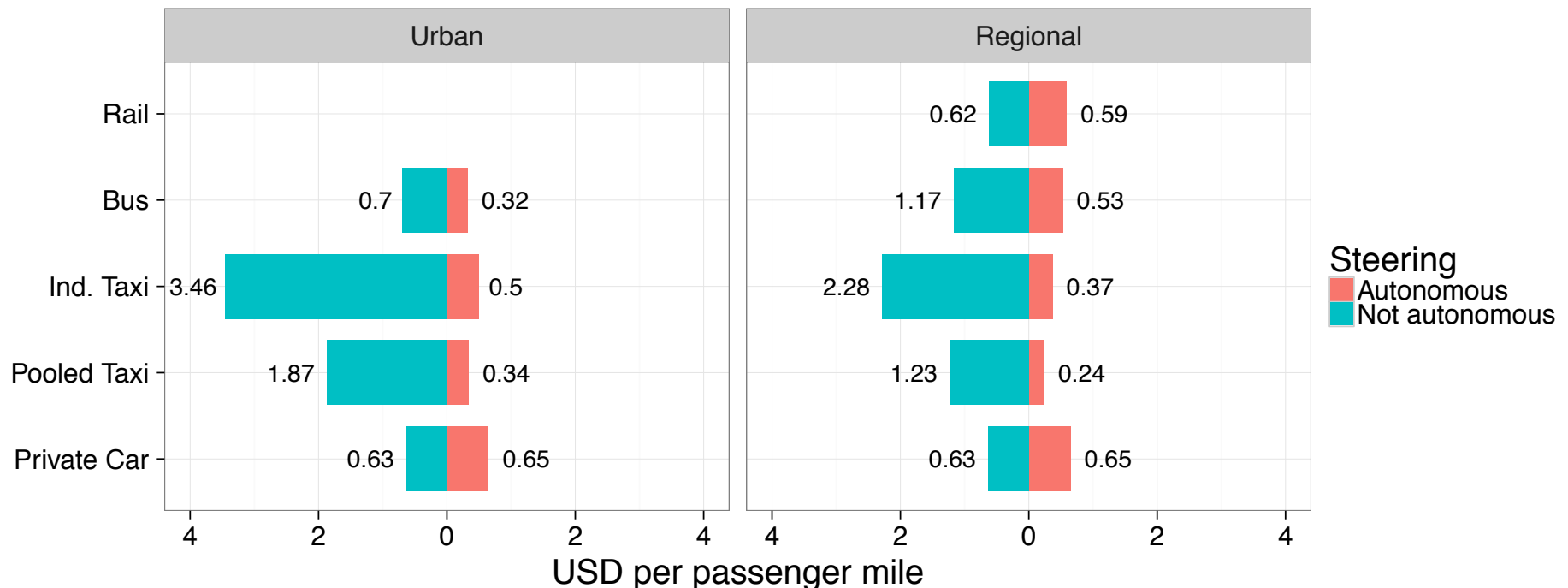# Some results – cost structure

Three key impacts of vehicle automation

AV technology

- raises the purchase price of a vehicle,

- lowers the marginal (operating) costs of a vehicle,

- allows vehicles to be operated driver-less
  (saving the driver's salary).

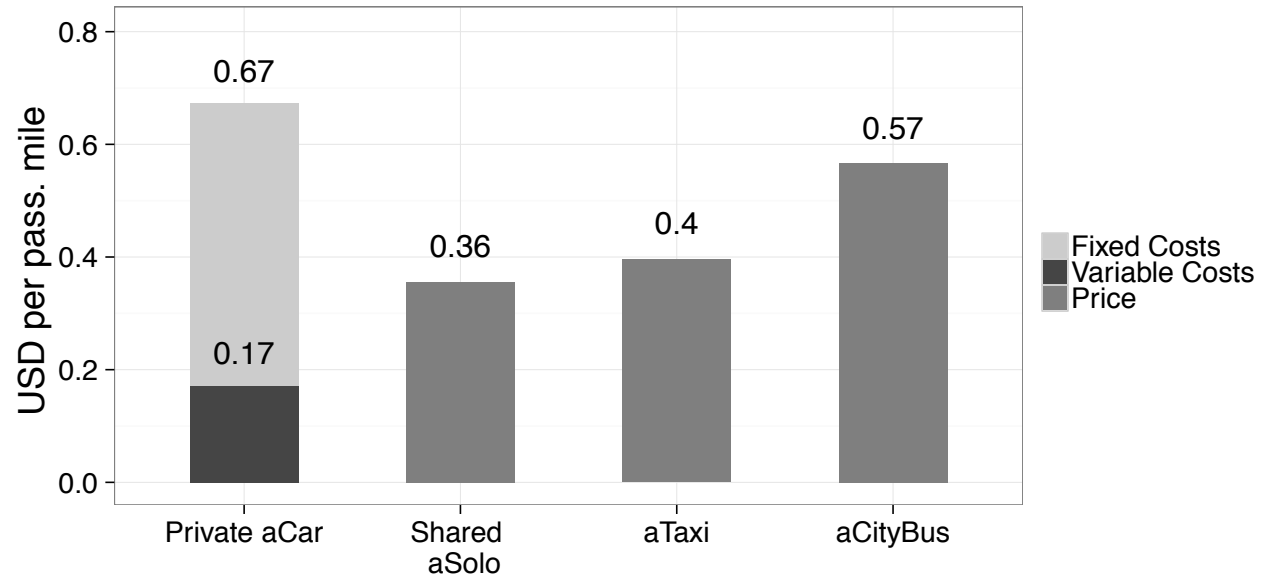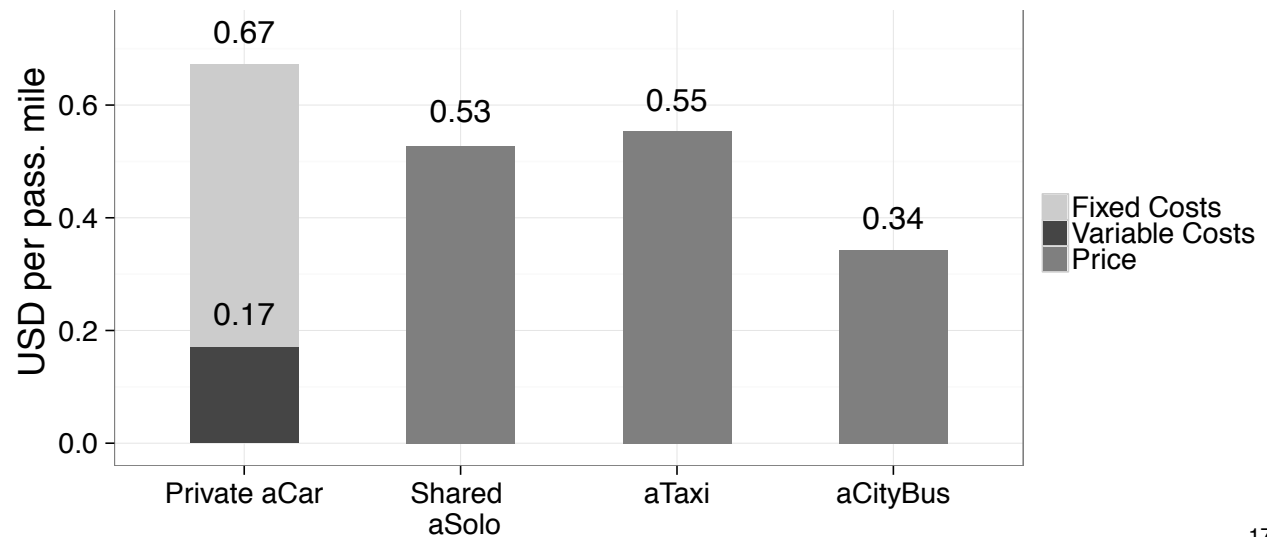# AV technology will level differences between modes

- operating cost

Original results valid for Switzerland and calculated in CHF. Conversion according to purchasing power parity 2016 (OECD; 1 USD = 1.22 CHF).

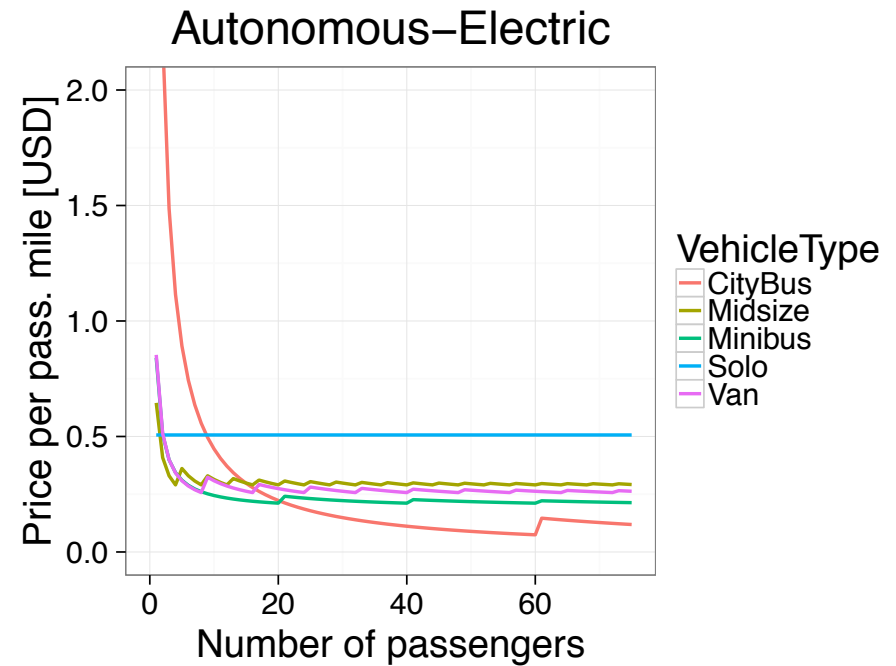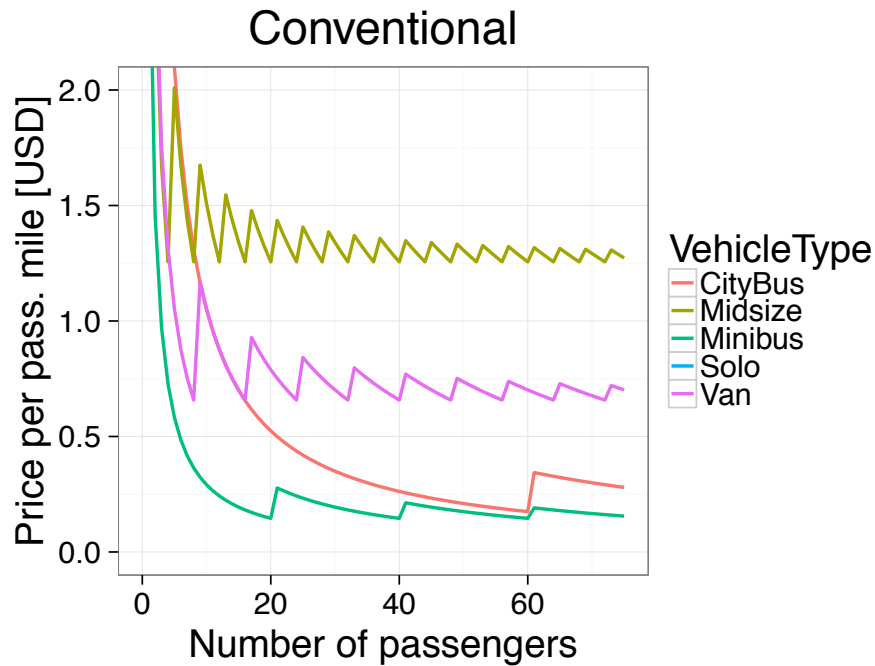# Prices: the private car will remain expensive/cheap

Differences between vehicle types also levelled

Conventional

Autonomous−Electric

Conclusions

Cost-wise...

- private car ownership will remain (very) attractive

- line-based public transportation will remain viable for high-demand relations

- (shared) taxis will replace line-based public transportation on low-demand relations

- one-seaters will be used for first-/last-mile connections if fleet heterogeneity is not a problem

Many questions are still open

- Validity of our assumptions?

- Vehicle design?

- Valuation of comfort, waiting times and transfers?

- Pricing schemes?
- Fare-integration of public transport and AV-taxis?

- Subsidies? Minimum level of service?
    - Income-adjusted rebates ?
    - Income and work-distance adjusted rebates ?
    - Fixed free kilometre budget ?

- User optimum vs. system optimum?

- ...

Thank you!

Meyer, J., H. Becker, P.M. Bösch and K.W. Axhausen (2017) Autonomous vehicles: The next jump in accessibilities?, *Research in Transportation Economics* (in press).

Bösch, P.M., F. Becker, H. Becker and K.W. Axhausen Cost-based Analysis of Autonomous Vehicle Services, *Transport Policy* (under review).