Preferred citation style

Chances and impacts of autonomous vehicles

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September 2017
Acknowledgments

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 assumptions

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)
Updated full cost/pkm estimate (current occupancy levels)

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<th>Urban</th>
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CHF per passenger kilometer

Steering
Autonomous
Not autonomous
Updated full cost/pkm estimate (current occupancy levels)

- Private aCar: 0.19 CHF (Fixed Costs) + 0.30 CHF (Variable Costs) = 0.49 CHF
- Shared aSolo: 0.20 CHF (Fixed Costs) + 0.31 CHF (Variable Costs) = 0.51 CHF
- aTaxi: 0.18 CHF (Fixed Costs) + 0.28 CHF (Variable Costs) = 0.46 CHF
- aCityBus: 0.08 CHF (Fixed Costs) + 0.18 CHF (Variable Costs) = 0.26 CHF
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

DVRP

- Model
- Optimiser

MATSim

- Mobility simulation
- Scoring
- Replanning
Simulation Framework: DVRP further extensions

- Single & multi passenger trips
- Demand-responsive simulation
- Multiple operators
- Full integration as ‘public transport’
Excursus: Homophily in shared rides

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
  • Maximize the degree of the social match
Number of matches by extra waiting time and criteria

- Maximum Cardinality Matching
- Maximum Weight Matching (approx.)
- Stable-preference Matching
Travel time by matching criterion

Maximise the social match
Minimise miles travelled of AVs
Minimise travel time of AVs
No sharing

Passenger travel time/trip [min]

CASA 17
Induced demand by AVs
## Induced demand elasticities from a pseudo-panel

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<td>Total distance travelled</td>
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2010 Switzerland general accessibility
Accessibility change for scenario 3/optimistic
Accessibility change for scenario 3/o 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?
References

