

How autonomous vehicles will affect the Swiss transport system: What we already know and what we can't know yet

NSL Colloquium: Transport planning: Where do we go now?

Alex Erath, 7th December 2023, ETH Zurich



INTRODUCTION

A NEW SET OF MODES

Autonomous ridehailing (aRH)



Source: Daimler

Autonomous ridepooling (aRP)



Source: Rinspeed

Service type

Door-to-door

Between pick-up points
As feeder to public transport

Cost

Competitive to car

Competitive to public transport

Travel time elements

Response time
Travel time

Response time
Travel time
Access / Egress time

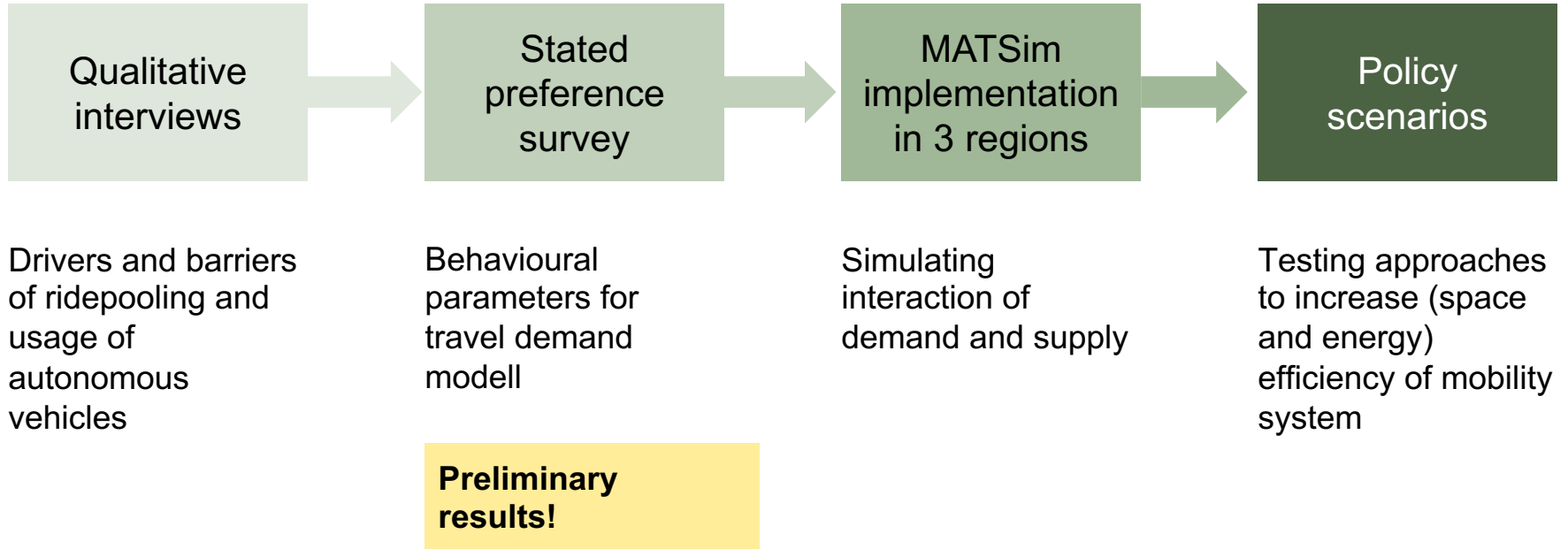
Travel time uncertainty

Due to traffic

Due to traffic and other passengers

INTRODUCTION

OUR STUDY AS PART OF THE RESEARCH PROJECT



Sponsor: Swiss Federal Roads Office FEDRO
Project ID: MB4 20 01A 01

Krueger *et al.* (2016)

- 3 alternatives: chosen mode, aRH, aRP
- “Prezi” slide show to explain aRH and aRP
- Classification of respondents according to their modality
- Travel time and cost: aRP >> aRH
- Waiting time: aRP and aRH >> public transport
- High a priori preference for aRH compared to aRP

Bansal and Daziano (2018)

- 3 alternatives: reported mode, aRH, aRP
- Information on (a)RH and (a)RP based on text and illustration
- Waiting and access time perceived 3x as much as in vehicle time

Becker *et al.* (2019) and Hörl *et al.* (2021)

- 6 alternatives, including aRP, aRH and aRH+PT
- 5159 choices from 453 respondents (Zurich area)
- Perception of travel time:
aRH-Feeder >> aRP / aRH > car > public transport
- Some key parameters only weakly significant

Choice experiment

- Pivot design based on reported trip
- 3 alternatives: chosen mode, aRH, aRP
- Information on (a)RH and (a)RP based on text and illustration

Results

Krueger et al. 2016

- Travel time and cost: aRP >> aRH
- Waiting time: aRP and aRH >> public transport
- High a priori preference for aRH compared to aRP

Bansal and Daziano (2018)

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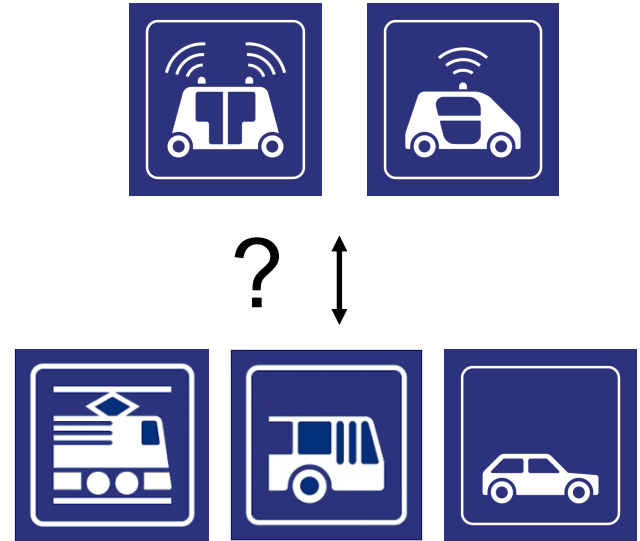
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INTRODUCTION

RESEARCH QUESTIONS

- How do behavioural parameters for ridehailing (aRH) and ridepooling (aRP) **compare to parameters of existing modes**?
- Which **additional parameters** for aRH and aRP **can we reliably quantify** with a nationwide stated preference survey?
- How do the new modes **impact car ownership**?
- Is there a **market for ridepooling travel cards**?





Bülach

Stadel bei
Niederglatt

Oberglatt

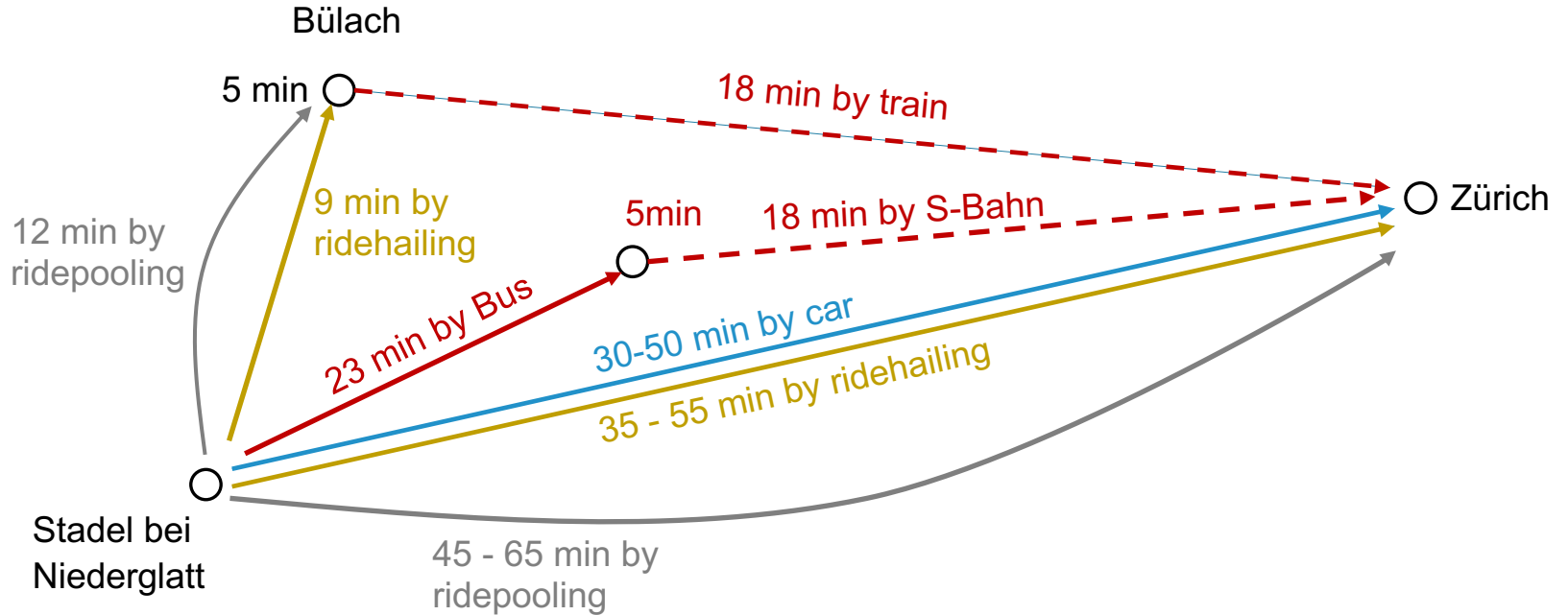
Zurich

Andrea's
*home sweet
home*









INTRODUCTION

OUR CASE STUDY: A 25KM TRIP TO THE CITY ON A THURSDAY EVENING



METHODOLOGY

OUR CASE STUDY AS A CHOICE EXPERIMENT

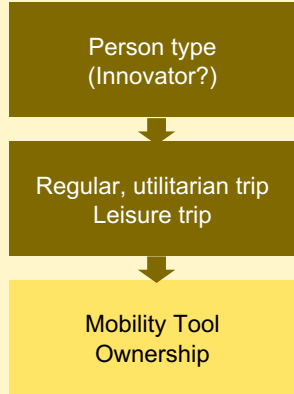
						
	Car	Public transport	aRH (direct)	aRH + PT (intermodal)	aRP (direct)	aRP + PT (intermodal)
	30-50 min	53 min	32 min	35- 55 min	35 min	45-65 min
	CHF 15	CHF 5	CHF 12	CHF 20	CHF 9	CHF 12
	-	1 transfer	1 transfer	-	1 transfer	-

Your choice:	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

METHODOLOGY

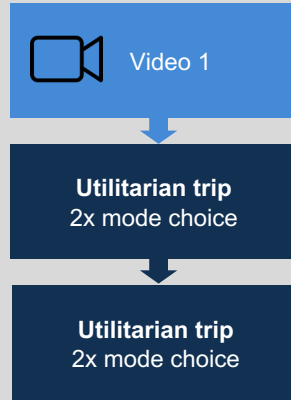
SURVEY

Screening / reported trip

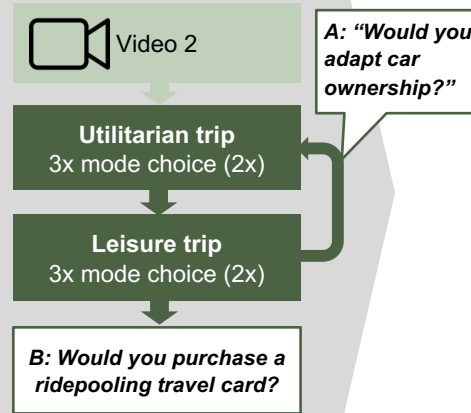


Generation of
customised
questionnaire

Ridepooling



aRP / aRH



Additional information on respondent

Modality and soft
factors

Socio-
demographics

Questionnaire 1

Questionnaire 2

Objectives:

- Ensure consistent information among all respondents
- Address concerns raised in exploratory interviews
- Easy to understand and watch

Addressed topics in video 2:

- AV technology
- Traffic safety
- **Vehicle types and new services**
- **Fare and travel cards**
- **Personal safety**



Fachhochschule Nordwestschweiz
Hochschule für Architektur, Bau und Geomatik

Wie funktionieren selbstfahrende Fahrzeuge?

Video in [German](#) / [French](#)

METHODOLOGY

ADAPTIVE PIVOT POINT EXPERIMENT DESIGN

Goal

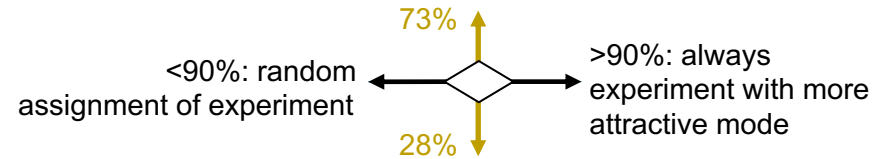
- Simple, realistic and efficient choice sets
- Can be implemented in a web-based questionnaire

Approach

- Choice set with 3 labelled alternatives
- Pivot random design based on reported trips
- Prices ranges for aRH and aRP based on Bösch et al. (2018)
- Attribute levels adaptive to trip length and spatial type of origin and destination
- Selection of alternatives based on attractiveness of aRP as direct mode vs. feeder mode

Choice set 1

Public transport	aRH (direct)	aRP (direct)
53 min	32 min	35 min
CHF 5	CHF 12	CHF 9
1 transfer	1 transfer	1 transfer
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



Choice set 2

Public transport	aRH + PT (intermodal)	aRP + PT (intermodal)
53 min	35- 55 min	60-70 min
CHF 5	CHF 20	CHF 12
1 transfer	-	-
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Desktop Browser

	Auto	Selbstfahrendes Taxi	Selbstfahrendes Ridepooling
Reisedauer	18 - 22 Min.	15 - 19 Min.	19 Min.
im Fahrzeug	18 - 22 Min.	15 - 19 Min.	13 Min.
Zu Fuss	0 Min.	keine Fusswege	6 Min.
Kosten inkl. Parkplatz	6 CHF (inkl. Parkplatz)	9 CHF	7 CHF
Wartezeit	-	10 Min.	2 Min.
Zusteigeort	-	Haustür	ÖV Haltestelle
Mitfahrende	-	keine Mitfahrenden	2 - 3 Pers.
Vorbestellung möglich	-	Ja	Nein
Entscheidung	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Mobile Browser

	Ridepooling
Reisedauer	42 Min.
im Fahrzeug	40 Min.
Fusswege zu/von Haltep.	2 Min.
Umsteigen	-
Kosten	72 CHF
Anzahl Umsteigen	Fahrt direkt
Auslastung im ÖV / Mitfahrende	2 - 3 Pers.
Takt	4 Min.
Zusteigeort	Virtueller Haltepunkt
Vorbestellung möglich	Ja
Ihre Wahl	<input type="radio"/>

Powered by Qualtrics

SAMPLING AND SAMPLE

intervista Webpanel

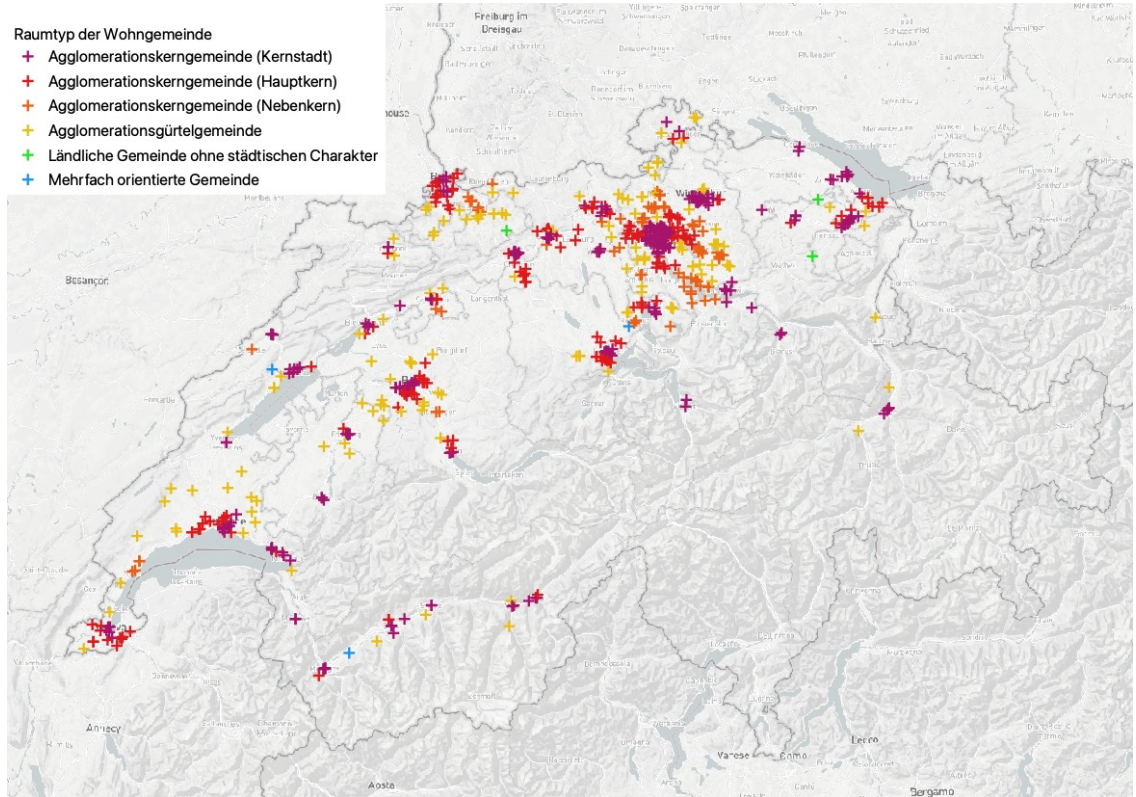
- 110k residents
- Stratified sample for spatial type of residence, innovation diffusion and various quotas

Deviation from national shares smaller than 5%

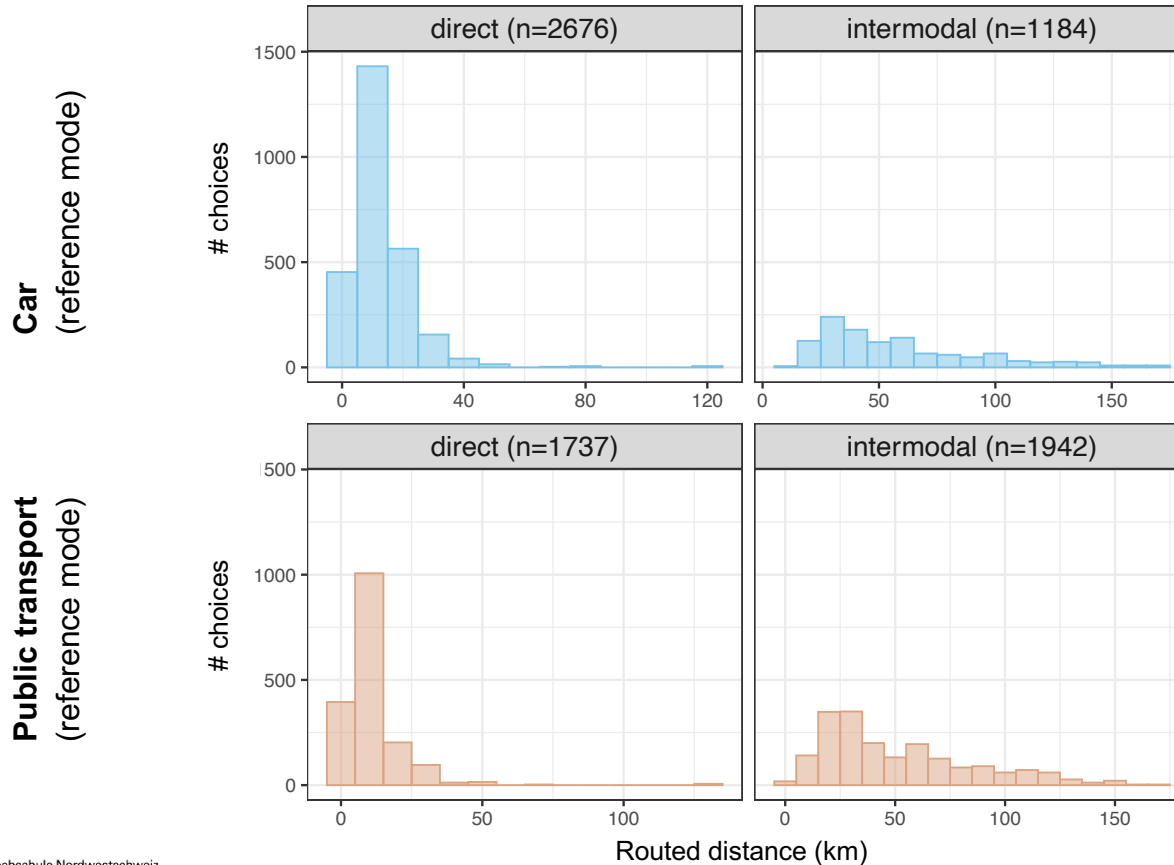
- Age groups
- Car availability
- Language (German and French)
- Spatial type of residence municipality

Slightly overrepresented groups

- GA and regional travel card (34% vs 20%) due to restrictions WRT trip distance
- 20% higher income than for reference population



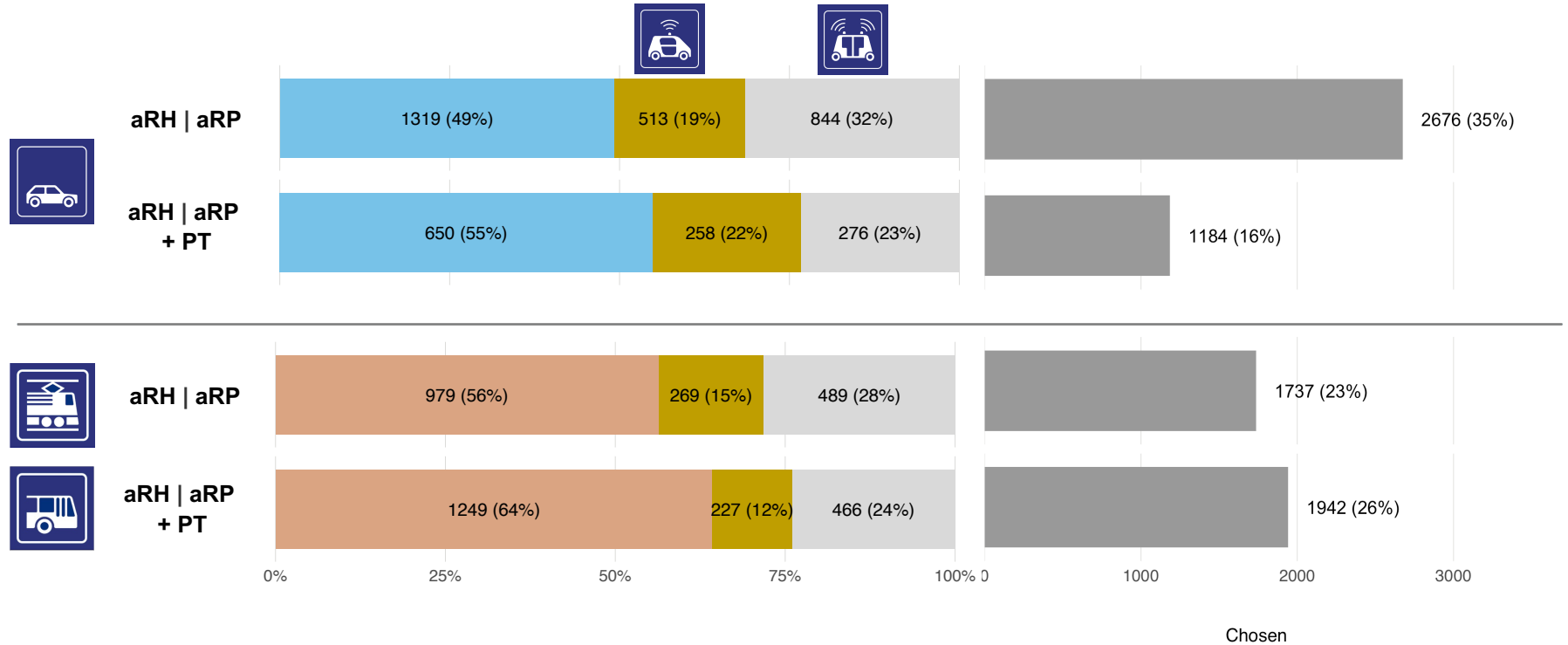
DISTANCE DISTRIBUTION OF REFERENCE TRIP BY EXPERIMENT TYPE



Total choices
n=7539

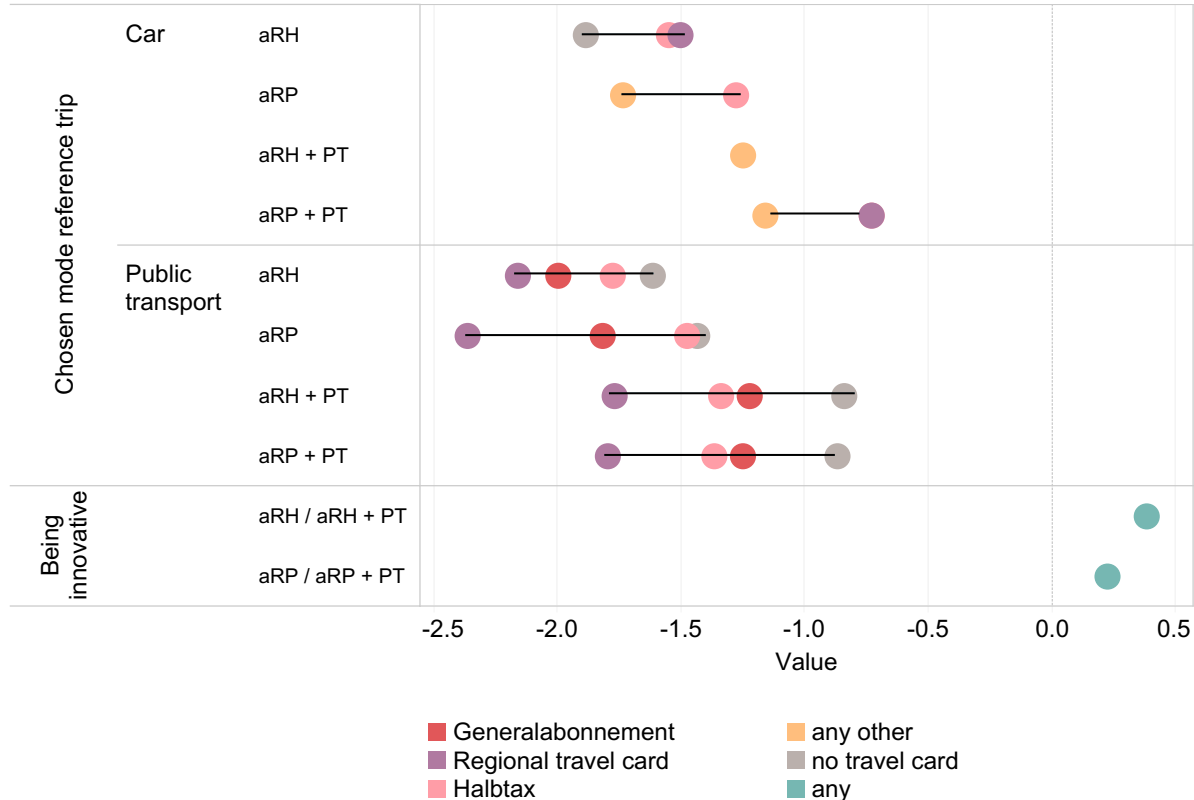
RESULTS

MARKET SHARES



RESULTS

CONSTANTS



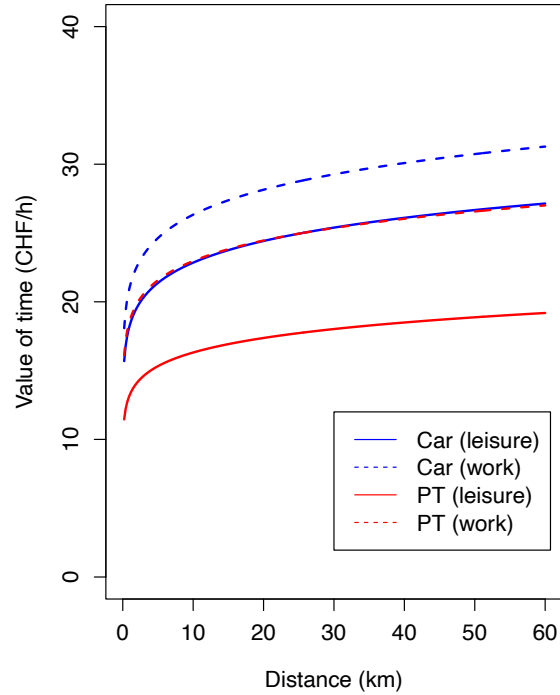
Insights:

- Respondents are rather hesitant to choose the new modes
- Car trips are more likely to be replaced by aRH or aRP
- No a priori preference for aRH
- Lower hesitation to choose aRH or aRP as part of an intermodal trip
- Car users with travel cards are more likely to use aRH or aRP
- PT users with travel cards are less likely to use aRH or aRP
- “Innovative” persons are more likely to use aRH or aRP

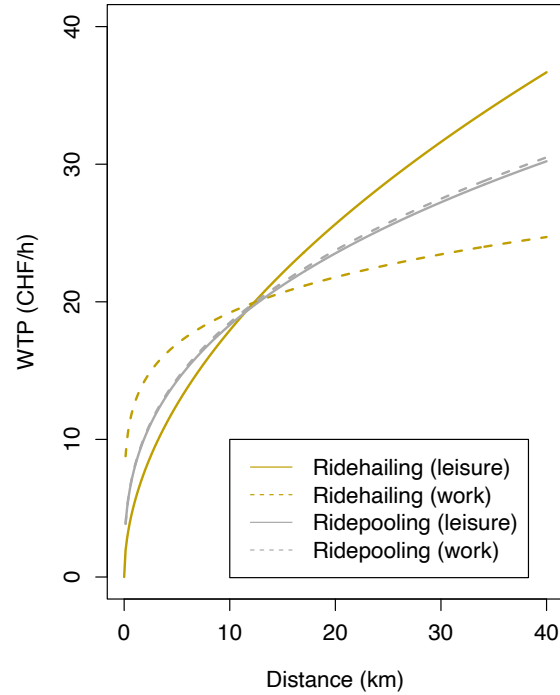
RESULTS

VALUES OF TIME

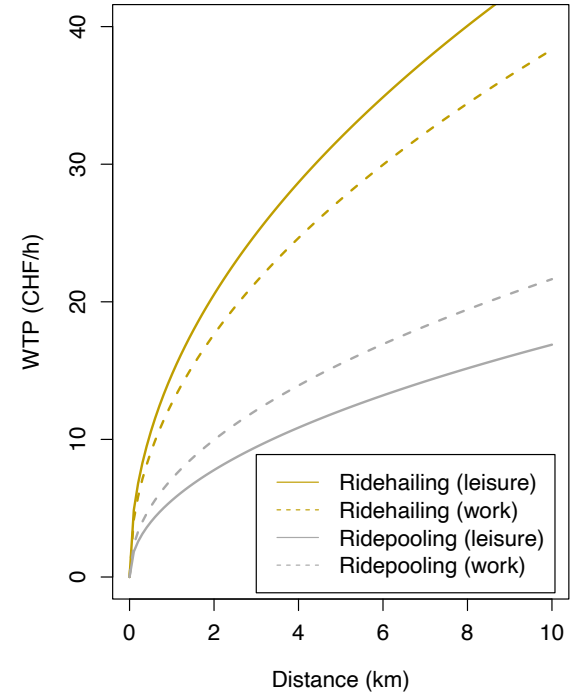
Existing modes



Ridehailing and ridepooling direct



Ridehailing and ridepooling as feeder



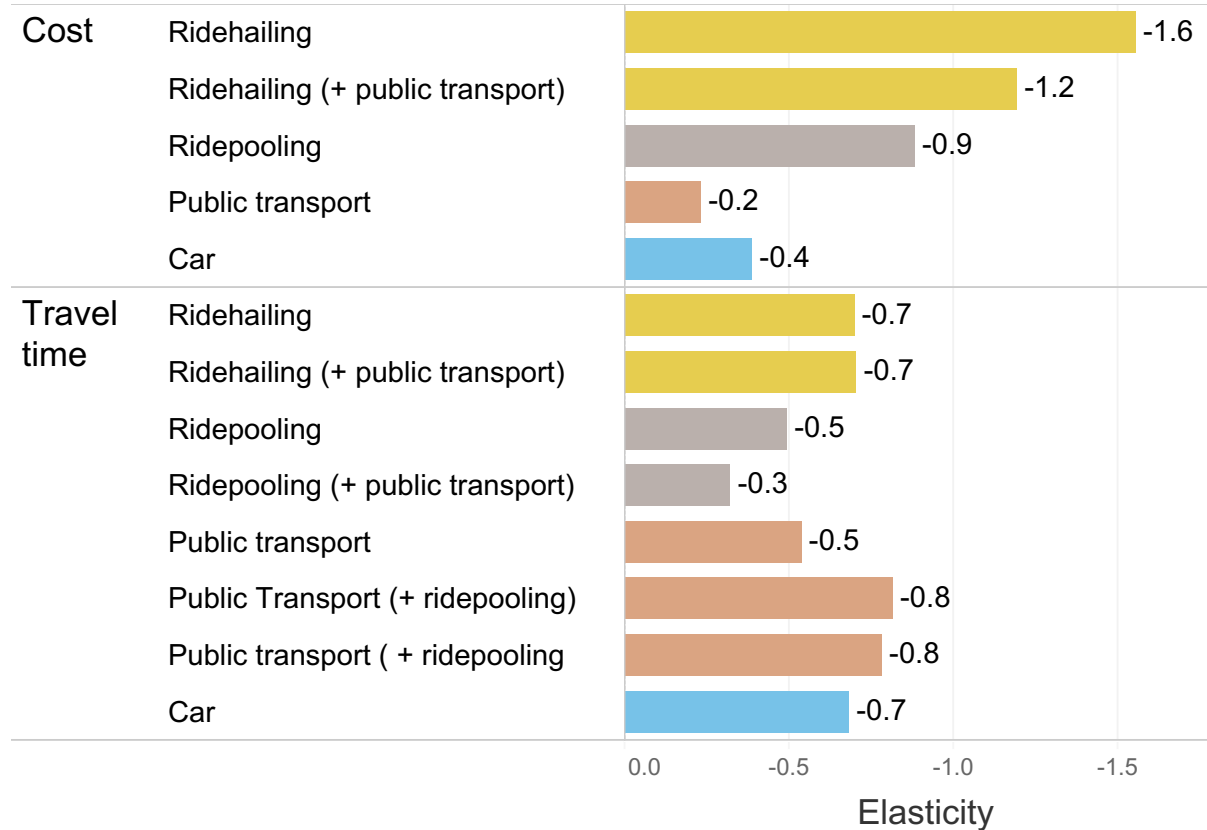
RESULTS

PARAMETER RATIOS

	Car	PT	aRH	aRH +PT	aRP	aRP + PT
Access vs. in-vehicle time	170%	200%	-	-	160%	
5 min transfer as in- vehicle time	-	9.6 min	-	10.9 min	-	14.1 min
Response time vs. in-vehicle time	-	-	30%		61%	
Bookable	-	-	3.3 CHF		1.3 CHF	
Travel time at high occupancy	-	+20%	-	-	insign.	insign.
Uncertainty: +/- 1 Min vs. in vehicle time	21%	-	insign.	insign.	44%	insign.
Headway vs. in vehicle time	-	26%	-	20%	-	26%

RESULTS

ELASTICITIES OF DEMAND WITH REGARDS TO...



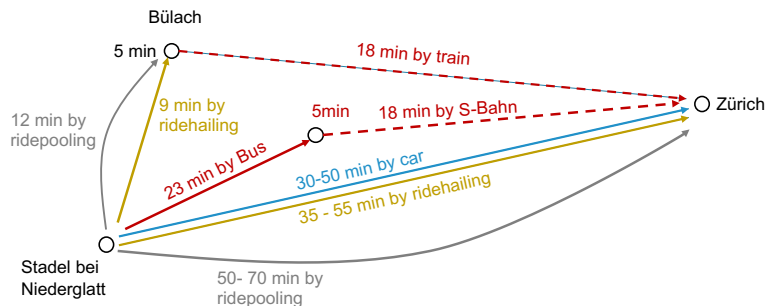
RESULTS

OUR CASE STUDY: 25KM TRIP TO THE CITY



Andrea

- Lives in Stadel bei Niederglatt
- Still owns a (old) car
- Has half fare card including aRP trips up to 10km



	Today	Today's view of the future	A less hesitant future
Car	74%	50%	28%
Public transport	26%	17%	10%
aRH	-	9%	21%
aRH + PT	-	4%	10%
aRP	-	5%	11%
aRP + PT	-	14%	20%
Veh-km on road	18.6	17.5	17.8
Pkm in public transport	7.1	8.7	9.0

DISCUSSION

Credible results

- Confirms insights from existing aRH/aRP-studies
- Adds new insights with regards to travel behaviour with aRH and aRP as direct and feeder mode

(Non-)confirmation of earlier findings

- Confirmation of earlier study by Becker / Hörl *et al.*
 - Hesitance to use aRP as compared to aRH identified by Krueger *et al.* cannot be confirmed: Switzerland as a “multimodal” nation?

New modes fill a gap

- For people who are neither public transport addicts nor petrol heads
- For areas with low public transport service quality

Limitations

- Influence of the number of additional passengers on willingness to pool could not be quantified.
- No nested structures tested (yet)
- No consideration of trips in groups (highly relevant for pricing of aRH and aRP)
- Competition with cycling not examined.

CONCLUSION AND OUTLOOK

Insights

- aRH and aRP can supplement existing modes and can lead to a more sustainable transport system
- Mobility pricing seems very effective to shift people from aRH to aRP
- aRP has limited potential as feeder service due to high transfer penalty

Contribution:

- New type of an adaptive pivot design choice experiment
- Wide set of credible and stat. sign. estimated behavioural parameters for aRH and aRP.

Outlook

- Implementation of choice model parameters in MATSim models
- Simulating where, when, and where the demand potential can be served with aRH and aRP supply.

Open (research) questions

- By how much will the hesitance towards the new modes will decrease as they become better known?
- How should we shape the Swiss transport system to leverage on shared autonomous vehicles and which role should aRP have?

HOW AUTONOMOUS VEHICLES WILL AFFECT THE SWISS TRANSPORT SYSTEM

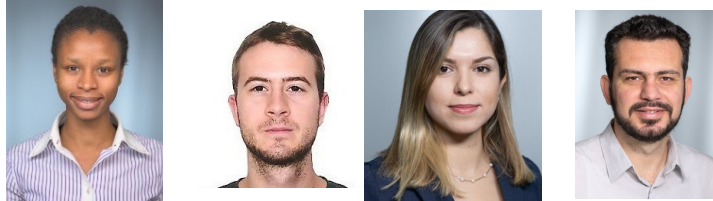
THANK YOU!



Understanding people's hopes
and concerns



Sketching, planning, designing,
implementing, conducting and
analysing stated preference
survey



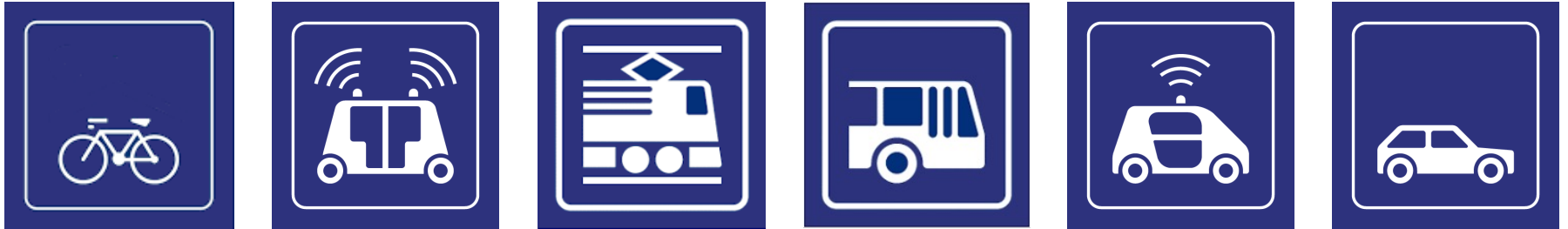
Contributing MATSim features,
setting-up & calibrating simulations
and running policy scenarios



Initiating, supporting, advising,
questioning, guiding, checking,
trusting.

HOW AUTONOMOUS VEHICLES WILL AFFECT THE SWISS TRANSPORT SYSTEM

QUESTIONS AND CONTACT



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<https://www.fhnw.ch/verkehr-und-mobilitaet>

HOW AUTONOMOUS VEHICLES WILL AFFECT THE SWISS TRANSPORT SYSTEM

LITERATURE

Bansal, P., Daziano, R.A., 2018. Influence of choice experiment designs on eliciting preferences for autonomous vehicles. *Transportation Research Procedia* 32, 474–481. <https://doi.org/10.1016/j.trpro.2018.10.044>

Becker, F., Axhausen, K.W., 2018. Predicting the use of automated vehicles for Zurich, Switzerland. Presented at the 15th International Conference on Travel Behavior Research (IATBR 2018). <https://doi.org/10.3929/ethz-b-000297579>

Bösch, P.M., Becker, F., Becker, H., Axhausen, K.W., 2018. Cost-based analysis of autonomous mobility services. *Transport Policy* 64, 76–91. <https://doi.org/10.1016/j.tranpol.2017.09.005>

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Krueger, R., Rashidi, T.H., Rose, J.M., 2016. Preferences for shared autonomous vehicles. *Transportation Research Part C: Emerging Technologies* 69, 343–355. <https://doi.org/10.1016/j.trc.2016.06.015>