Intertemporal VTT changes in Switzerland

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Outline

1. Background
2. Changes in survey methodology
3. Original model specification
4. Data description and summary statistics
5. Proposed methodology to account for reference dependency

Motivation and background

- Four national SP surveys conducted since 2010
- Directly linked to the revealed preference (RP) survey MTMC
  – pivoted SP experiments for observed reference trip
  – representative datasets with high response rates
- Empirical basis for the National Passenger Transport Model (NPVM), MATSim and VTT studies (CBA)
- One additional VTT study in 2021 by ETH (D-CH)

$\Longrightarrow$ **Data pooling** usually improves model robustness and identification (e.g. VTT for each trip purpose)

- However, substantial VTT differences btw. studies
- **Are differences in VTT artifacts of methodological changes** (see e.g. Börjesson *et al.* (2023) for SE and NL)?

Changes in survey methodology

2010 Establishes **personalized RP/SP setting**; relatively simple SP designs with small deviations; PAPI with large tables

2015 Survey **intentionally kept comparable** to 2010; mostly minor technical **improvements incl. trip routing**

2021 VTT study (by ETH; CAWI) for D-CH workers; **symmetric designs**; **focus on regular** work, shopping and leisure **trips**

2021 Modified experimental designs, improved trade-offs and routing; introduction of CAWI; **RP trip selection algorithm**

2025 **Simpler and cleaned-up** attribute sets; **more realistic** trade-offs; **table-based layout** with individual time/cost components; PT crowding by SBB; **more personalized** tasks

Changes in survey methodology

	öV-Route 1	öV-Route 2
Reisedauer		
Fahrtzeit:	12 min	22 min
+ Zu- und Abgangszeit:	11 min	23 min
+ gesamte Umsteigezeit:	4 min	4 min
Reisekosten		
Fahrtkosten:	2.60 CHF	3.80 CHF
+ Zuschlag zu Stosszeiten:	2.30 CHF	0.60 CHF
Umsteigevorgänge	1	1
Takt: Verbindung alle ...	30 min	20 min
Auslastung		
	○	○

Changes in survey methodology

- VTT 2021 and ARE 2025: **Methodological break** in the calculation of car reference travel costs
- Fuel/energy costs ($\approx$ **0.12 CHF/km**) represent only a fraction of the economically relevant variable costs ($\approx$ **0.3 CHF/km**), especially in the age of EVs
- **Improved comparability** between car and PT
- Variable costs are **standard in CBA** (e.g. ASTRA, 2022) and relevant in the **NPVM**

$\Longrightarrow$ Using a **consistent cost concept** in **behavioral model** and **downstream applications** improves the comparability and transferability of results!

WTP original specification

- Focus on **route choice** experiments (e.g. Hess *et al.*, 2017)
- **Multiplicative error** structure (Fosgerau and Bierlaire, 2009)
- Income and cost attributes are in **2025 prices**
- "Simple" methodology (comparable to previous CH modeling efforts; see e.g. Weis *et al.*, 2021; ARE, 2024):

$$V_{i,n,t} = -\psi_n \log\left(x^{tc}_{i,n,t} + (1+\mu^{mp})x^{mp}_{i,n,t} + \boldsymbol{x}_{i,n,t}\beta\right) \quad (1)$$

$$\psi_n = \exp\left(\beta^{scale}\right)\left(\frac{dist_n}{20\ \text{km}}\right)^{\lambda^{scale}} \quad (2)$$

$$\beta^k_n = \beta^k \left(\frac{dist_n}{20\ \text{km}}\right)^{\lambda^k}\left(\frac{inc_n}{7\ \text{kCHF}}\right)^{\lambda^{inc}} \quad (3)$$

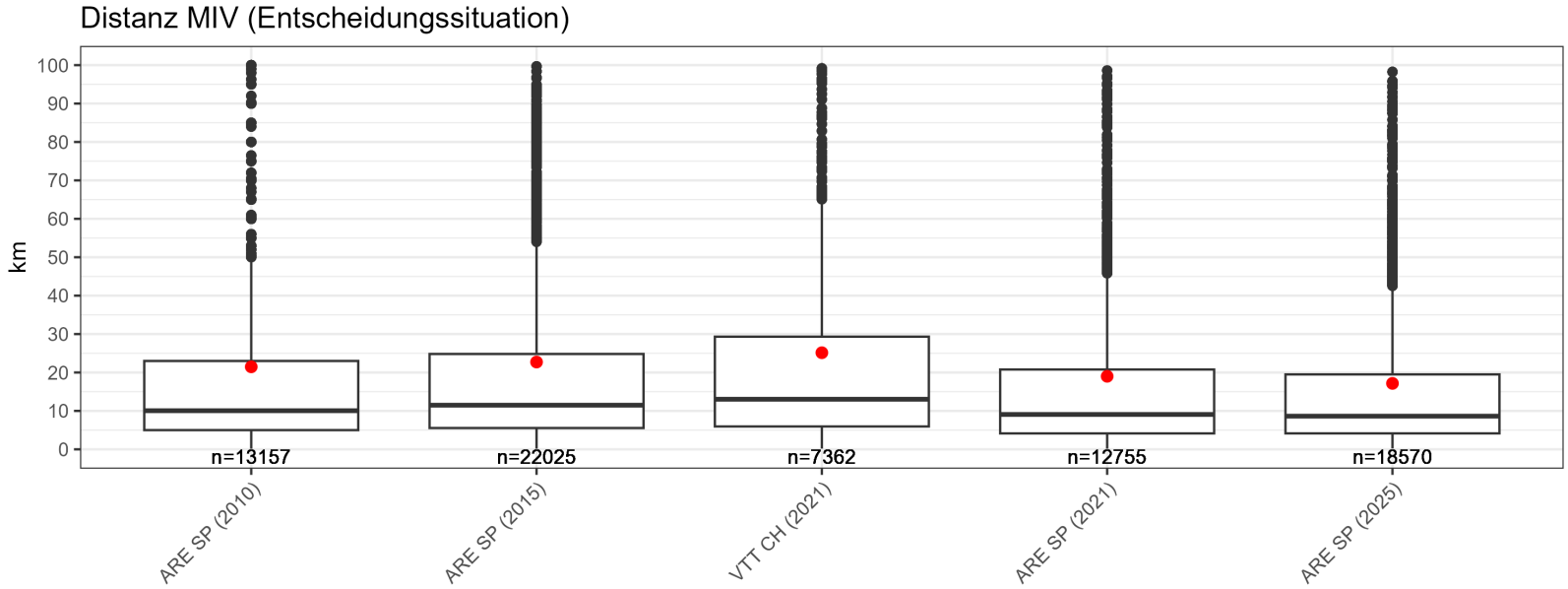
Respondent characteristics since 2010

Characteristic	ARE SP (2010)	ARE SP (2015)	VTT CH (2021)	ARE SP (2021)	ARE SP (2025)
# respondents (RC car)	2'225	2'947	1'227	2'151	3'099
# respondents (RC PT)	796	855	565	667	1'544
Age (years)	50.5	47.7	40.5	50.8	?
HH income (CHF/month)	8'354	9'559	10'847	10'046	?
HH size	2.4	2.7	2.7	2.6	?
GA travelcard (%)	12.4	11.0	15.6	10.6	?
Regional travelcard (%)	14.5	14.9	11.4	10.0	?
Car always available (%)	69.0	69.2	68.5	69.0	?
Work trips (%)	25.7	27.4	34.1	32.0	24.8
Education trips (%)	2.8	2.9	0.0	3.4	1.9
Shopping trips (%)	24.6	22.0	33.8	29.8	32.6
Business trips (%)	5.1	4.4	0.0	6.4	1.9
Leisure trips (%)	41.7	43.3	32.0	28.3	38.8

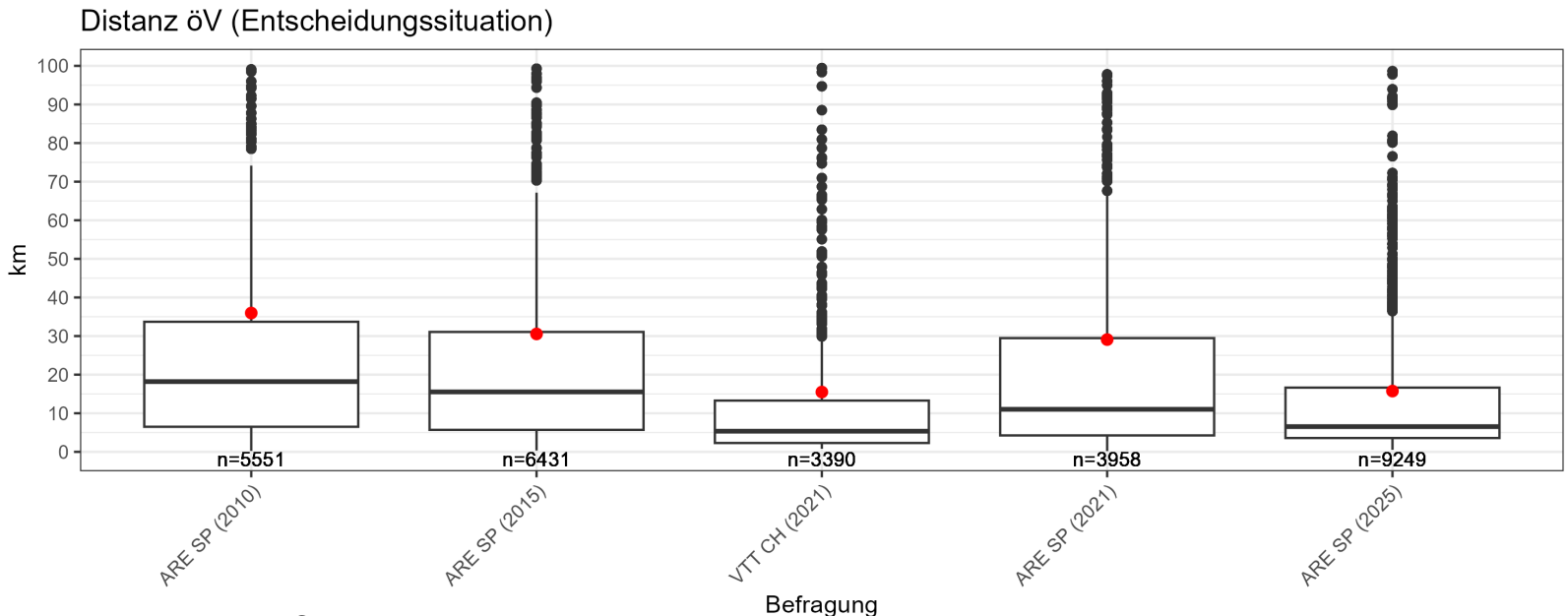
- Datasets mostly homogeneous (except VTT 2021 study)
- HH-income noticeably smaller in 2010

RP trip distance [km] since 2010

Car

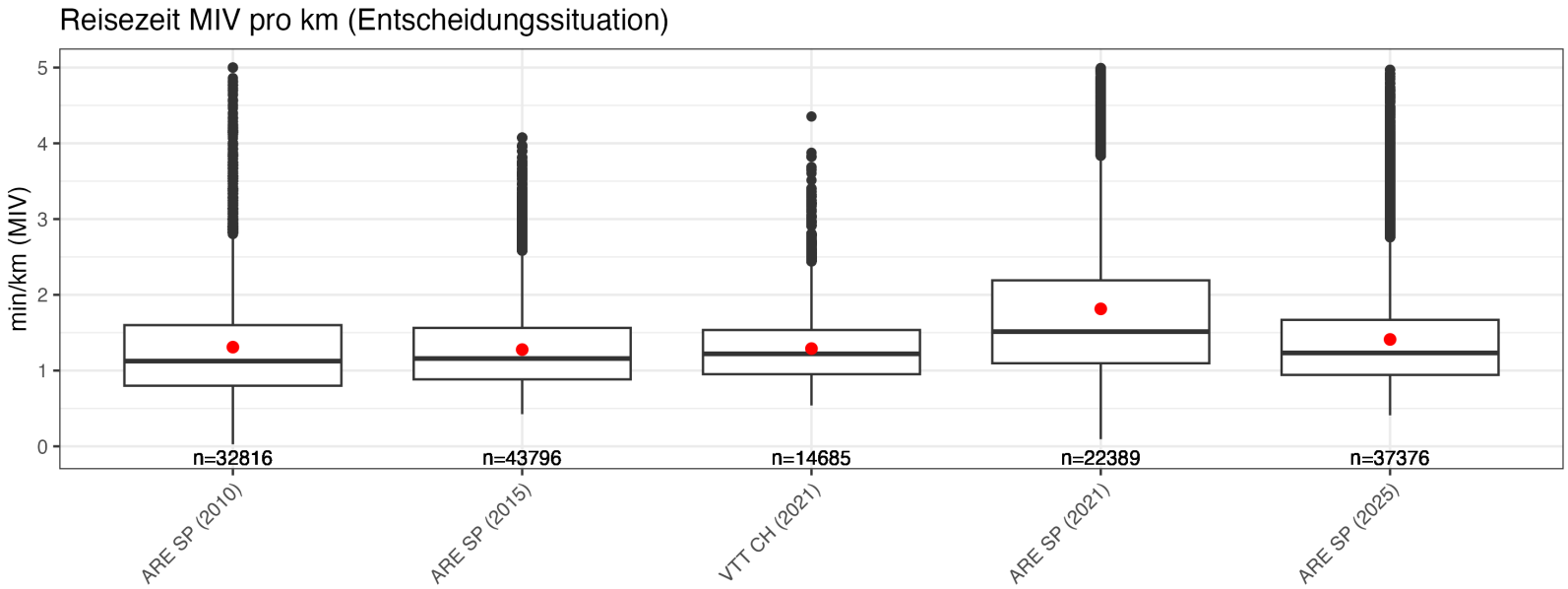


PT



Inverse speeds [min/km] since 2010

Car



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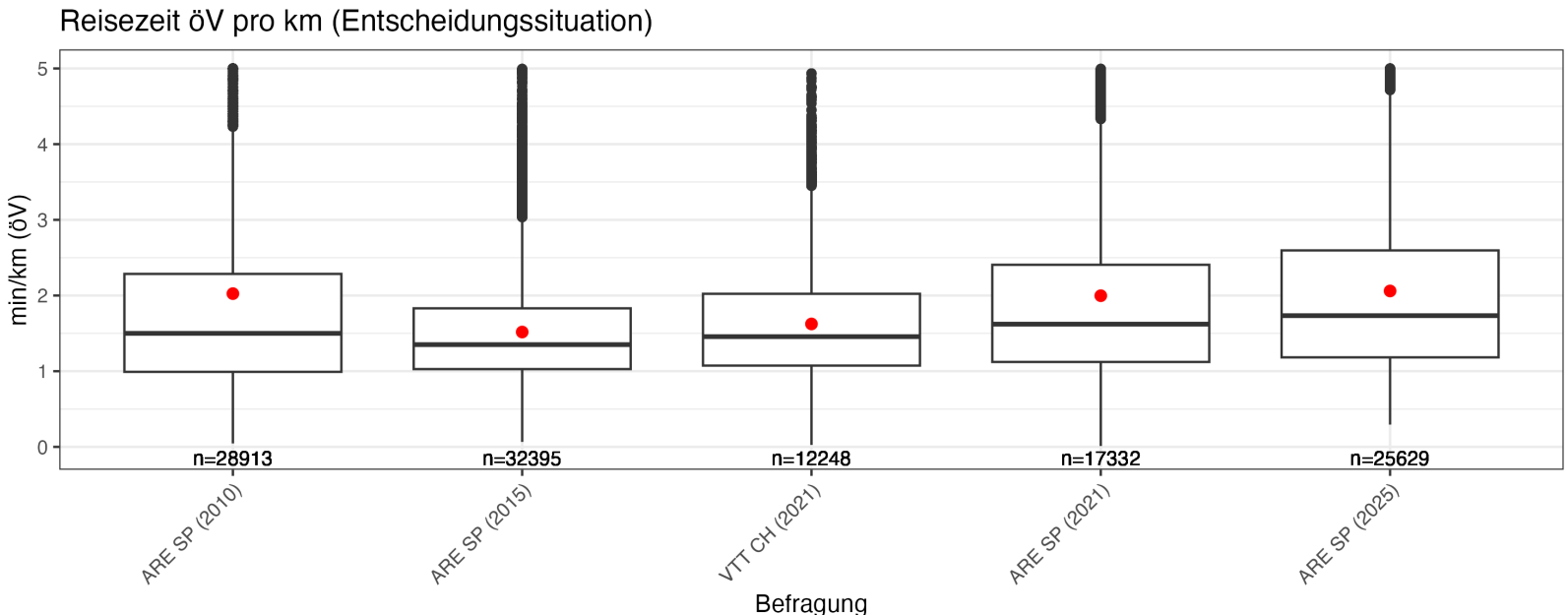
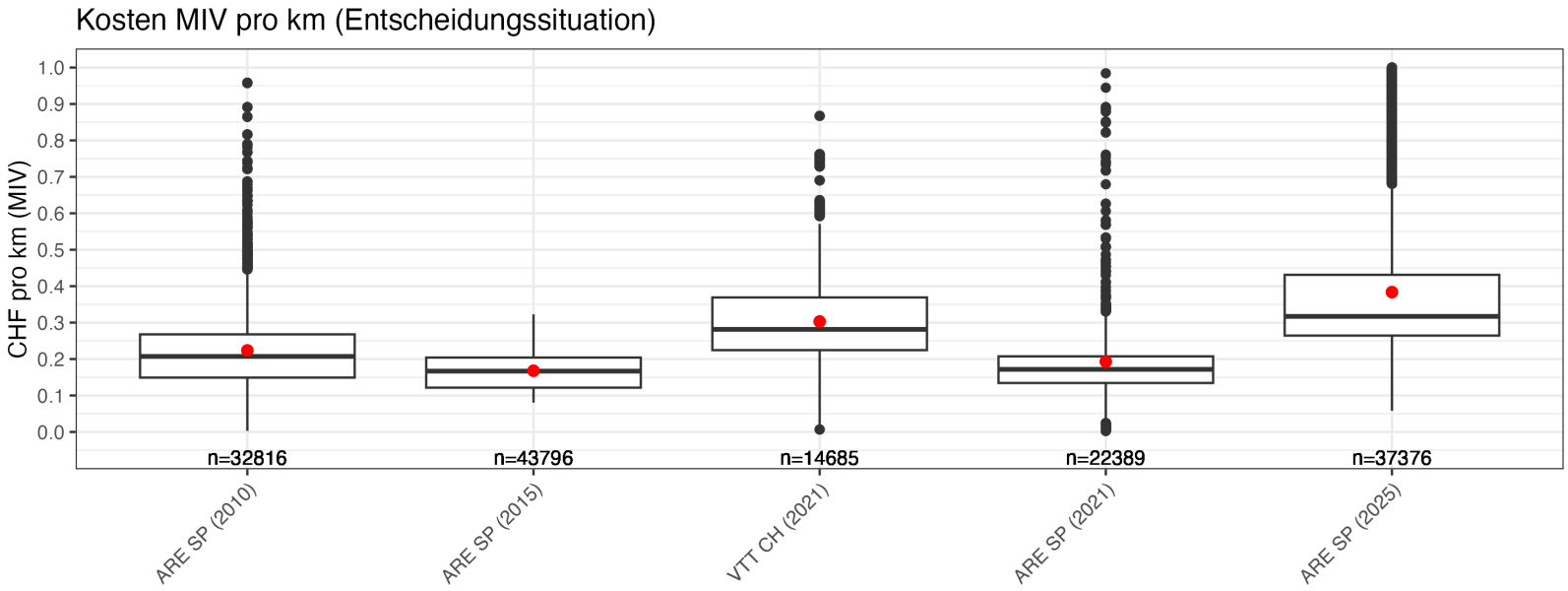
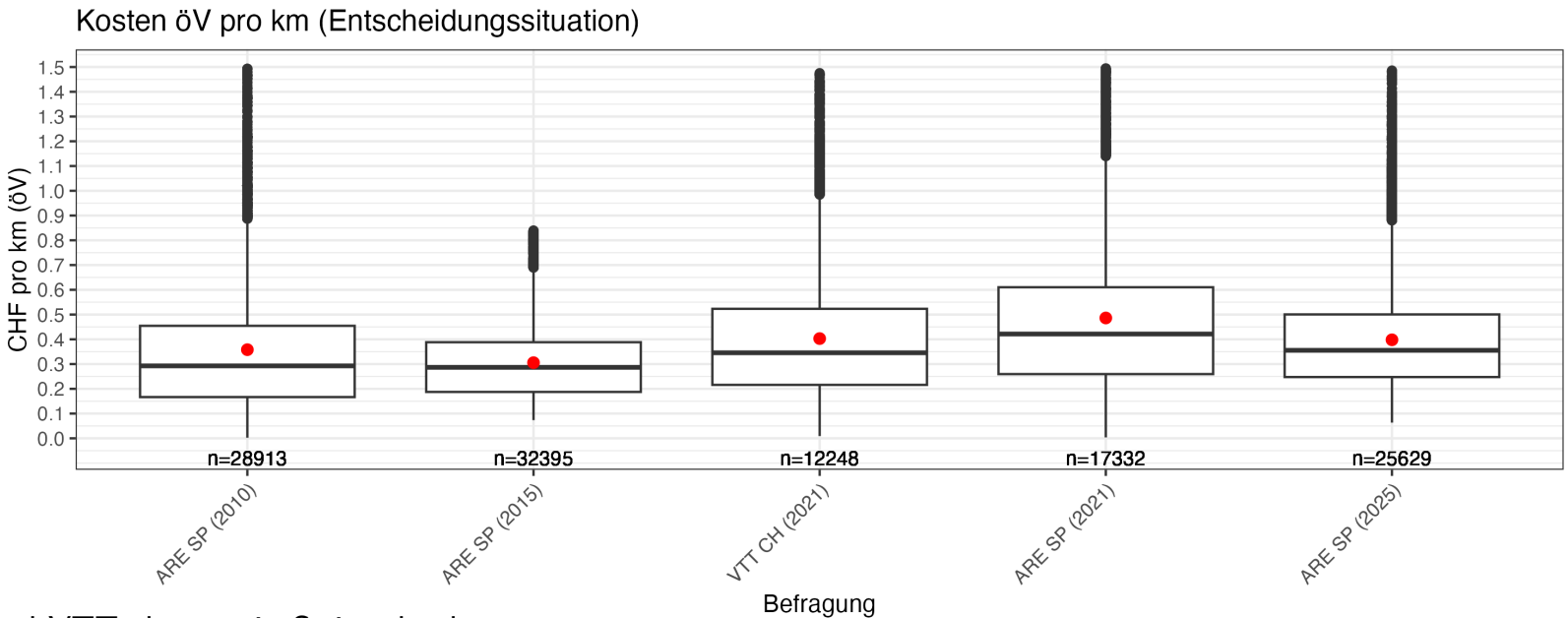


Cost per km [CHF/km] since 2010

Car

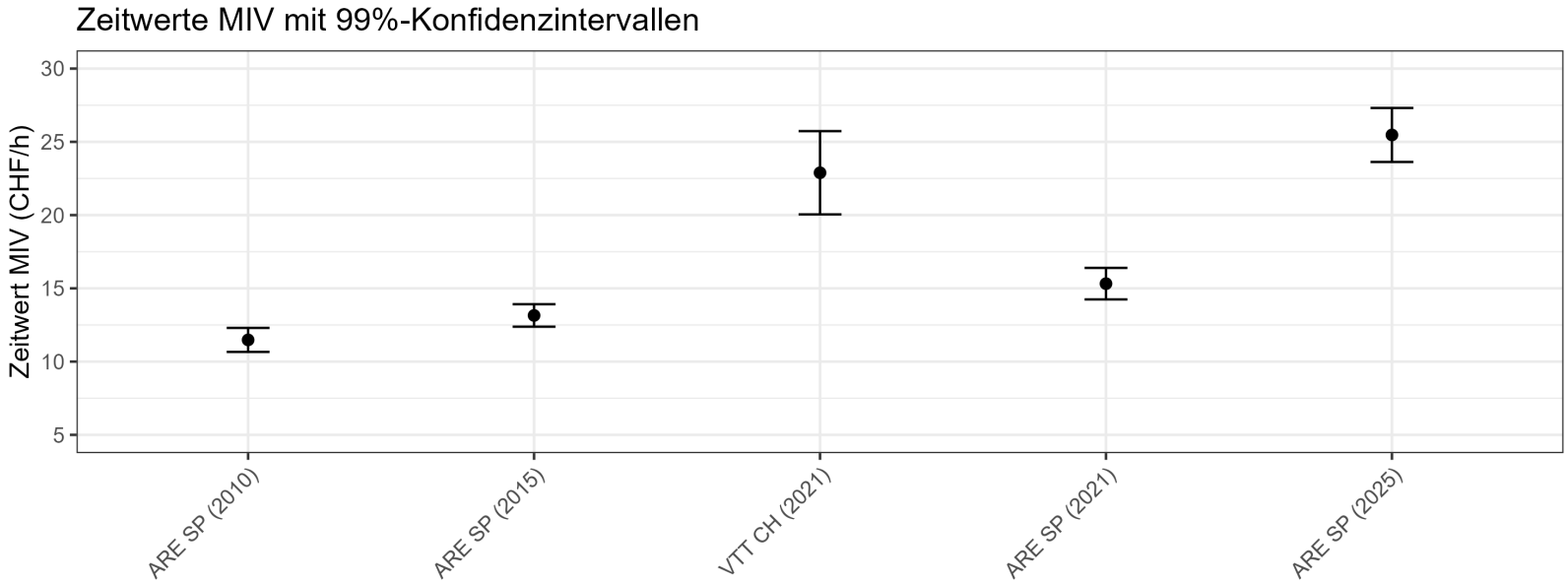


PT

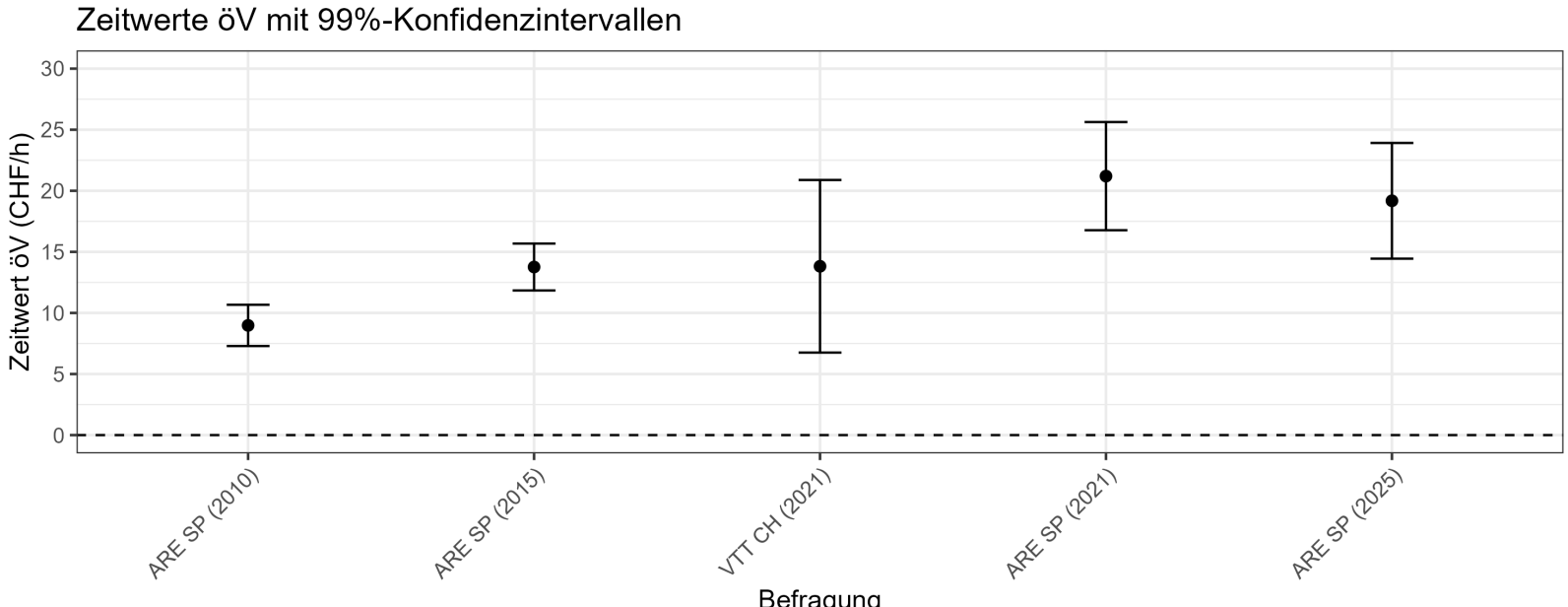


VTT [CHF/h] with WTP specification

Car

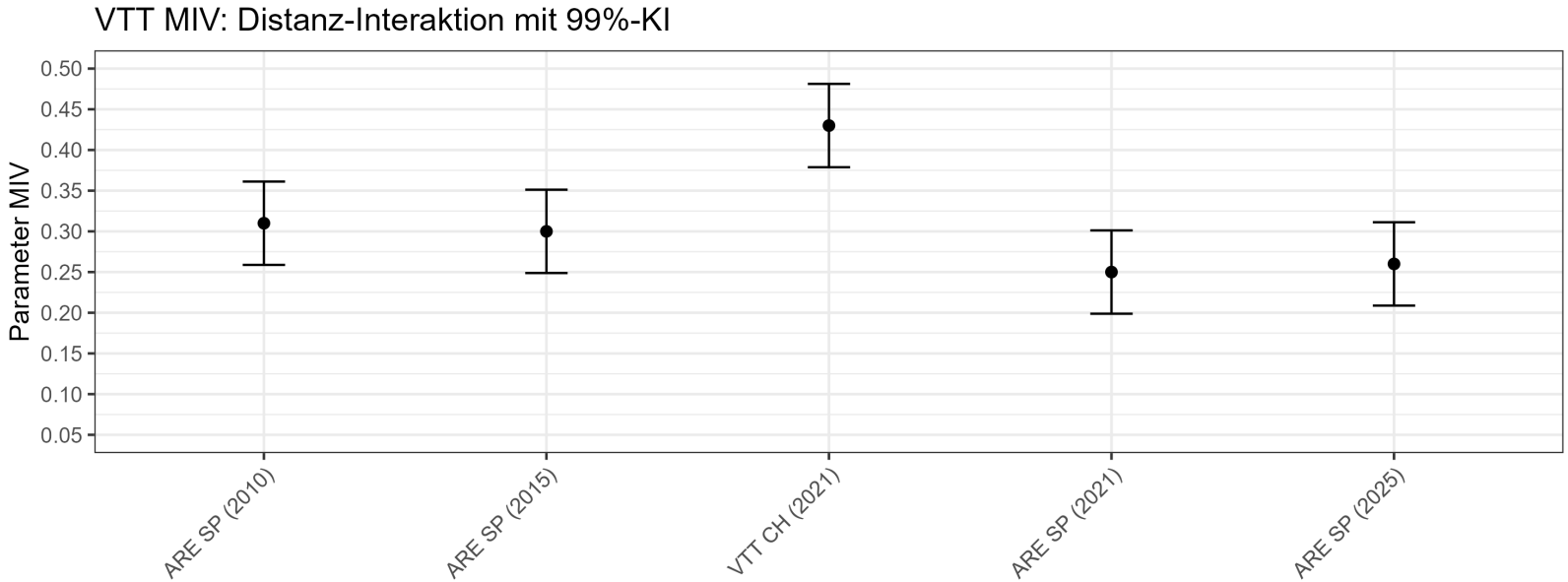


PT

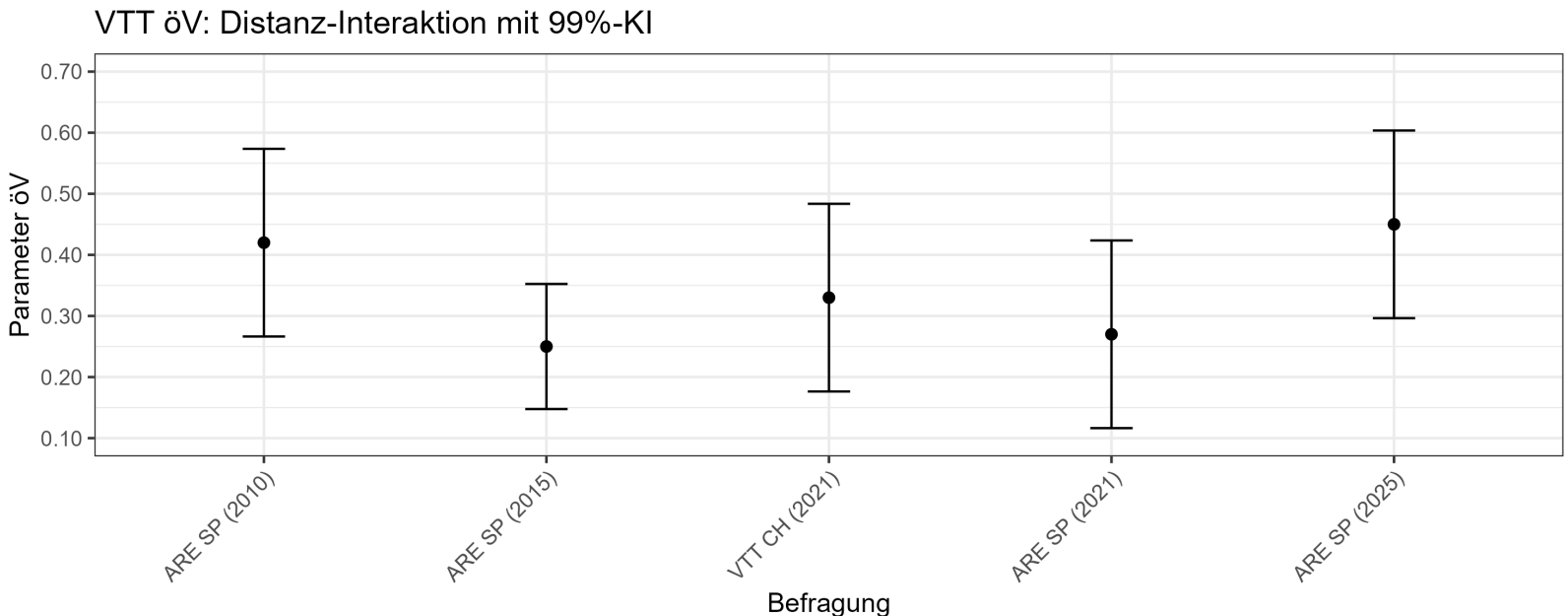


VTT distance elasticity with WTP spec.

Car



PT



Reasons for intertemporal VTT changes

Car VTT differences too large/incoherent to be explained by ...

- Survey methods, SP design and/or questionnaire layout
- Trip characteristics (distance, purpose, etc.)
- Sociodemographics (income, education, age)
- Response behavior and/or survey commitment
- Time-use during travel ($VTT = VoL - VTAT$)
- COVID-19

Is there a level effect of travel costs?

Are VTT affected by the cost levels?

Consider a simple linear utility specification:

$$V_{i,n,t} = \beta_{tt} x^{tt}_{i,n,t} + \beta_{tc} x^{tc}_{i,n,t}$$

The VTT is given by the MRS btw. travel time and cost:

$$VTT = \frac{\partial V / \partial x^{tt}}{\partial V / \partial x^{tc}} = \frac{\beta_{tt}}{\beta_{tc}}$$

For a given behavioral response and time sensitivity, higher costs imply that the same variation can be explained with a smaller β_{tc}:

$$x^{tc} \uparrow \quad \Rightarrow \quad |\beta_{tc}| \downarrow \quad \Rightarrow \quad VTT = \frac{\beta_{tt}}{\beta_{tc}} \uparrow$$

Ultimate question: What is the "actual" behavioral response?

Introducing reference dependence

- **Decisions** are made **relative to a reference point** rather than in absolute terms (Tversky and Kahneman, 1991)
- Travel time and cost increases are typically valued differently from equivalent decreases (De Borger and Fosgerau, 2008; Hess *et al.*, 2008; Börjesson and Eliasson, 2014)
- RP trip is assumed to define individual reference point
- **Hypothesis:** Respondents anchor to the attribute range shown in the SP experiment (rather than to the reference trip)
- This is **most relevant for car travel costs**:
  - **asymmetric** cost levels (particularly in ARE 2025)
  - only **vague idea** of actual car **reference costs**

Proposed methodology

- De Borger-Fosgerau-approach not feasible (≥ 3 attributes)
- Use average cost of individual n and SP choice situation t, $\bar{c}_{n,t}$, as reference point:

$$V_{i,n,t} = -\psi_n \log\left(\frac{x^{tc}_{i,n,t}\,\vartheta^{tc}_{i,n,t} + (1+\mu^{mp})\,x^{mp}_{i,n,t}}{\bar{c}^{\tau}_{n,t}} + x^{tt}_{i,n,t}\,\beta^{tt}_{n}\,\vartheta^{tt}_{i,n,t} + ..\right)$$

- Accounting for sign and size effects relative to $\bar{c}_{n,t}$ (ϑ^{tc} and ϑ^{tt}; multiplicative with mean $= 1$)
- Core idea: **Disentangling estimation** and final **VTT calculation**, for $\bar{c}_{n,t}$ using the variable trip costs in the MTMC:

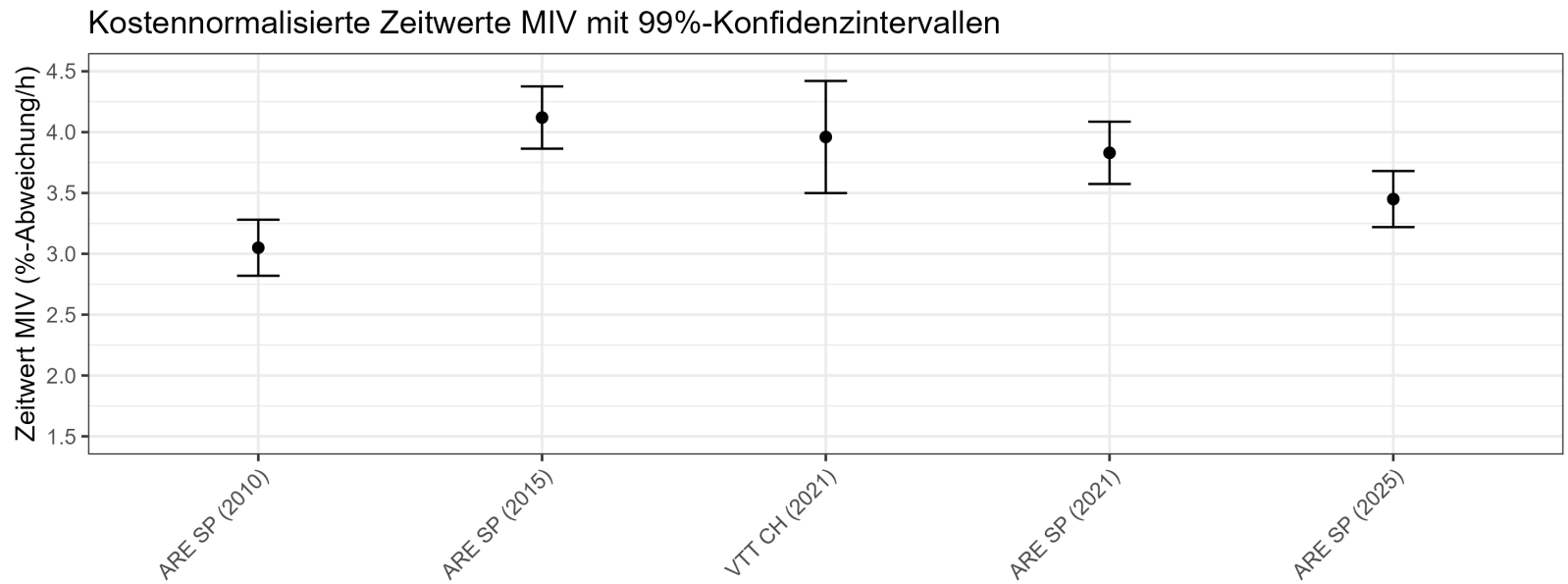
$$VTT_n = \mathbb{E}_{\vartheta}\left[\frac{\partial V/\partial x^{tt}}{\partial V/\partial x^{tc}}\right] \approx \widehat{\beta}^{tt}_{n}\,\widehat{\bar{c}^{\tau}_{n,t}}.$$

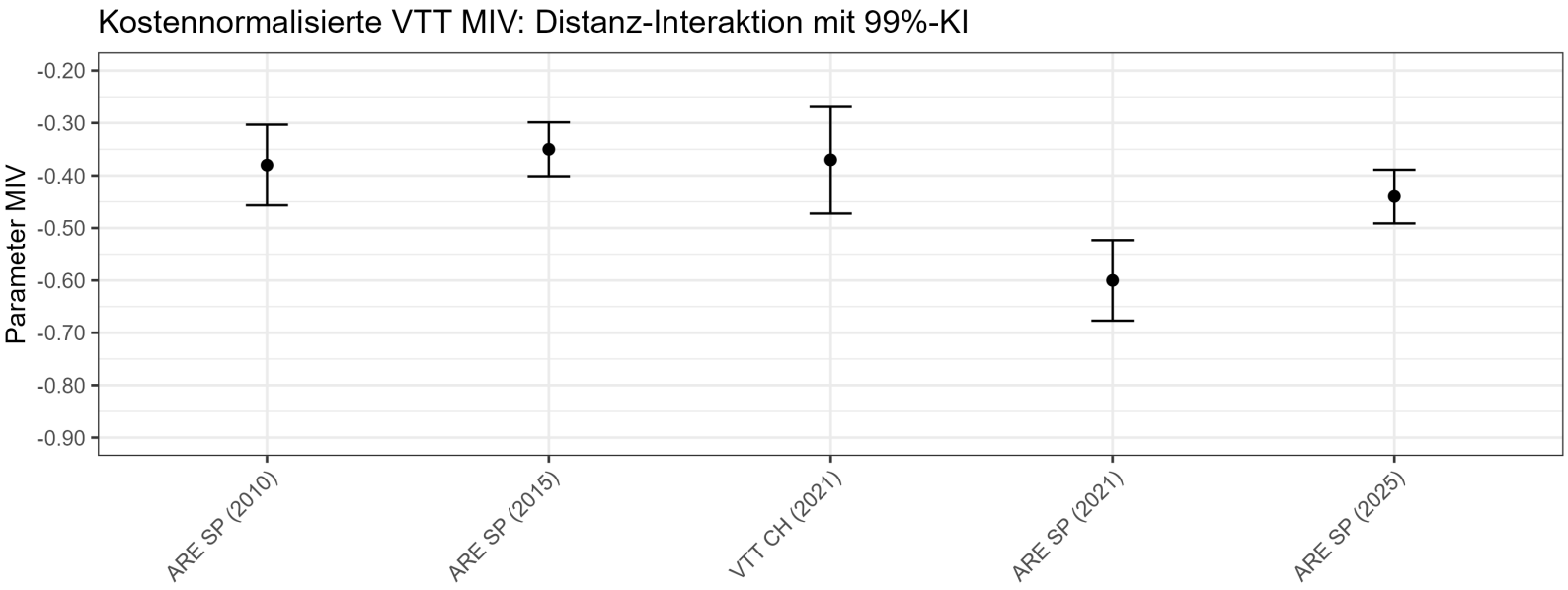
Results

- **Car route choice**: Accounting for full (i.e., $\tau = 1$; zero cost-level effects) reference point dependence improves comparability and model fit of individual datasets
- E.g. ARE 2025: Strong evidence for $\overline{c}$ instead of c_{ref} $\left(\frac{\overline{c}}{c_{ref}}\right)^{\theta} \cdot c_{ref} \implies \widehat{\theta} = 0.88$; $\widehat{\tau} = 0.76$ with θ fixed to 1
- E.g. ARE 2015 (survey with lowest CHF/km): $\widehat{\tau} = 0.36$

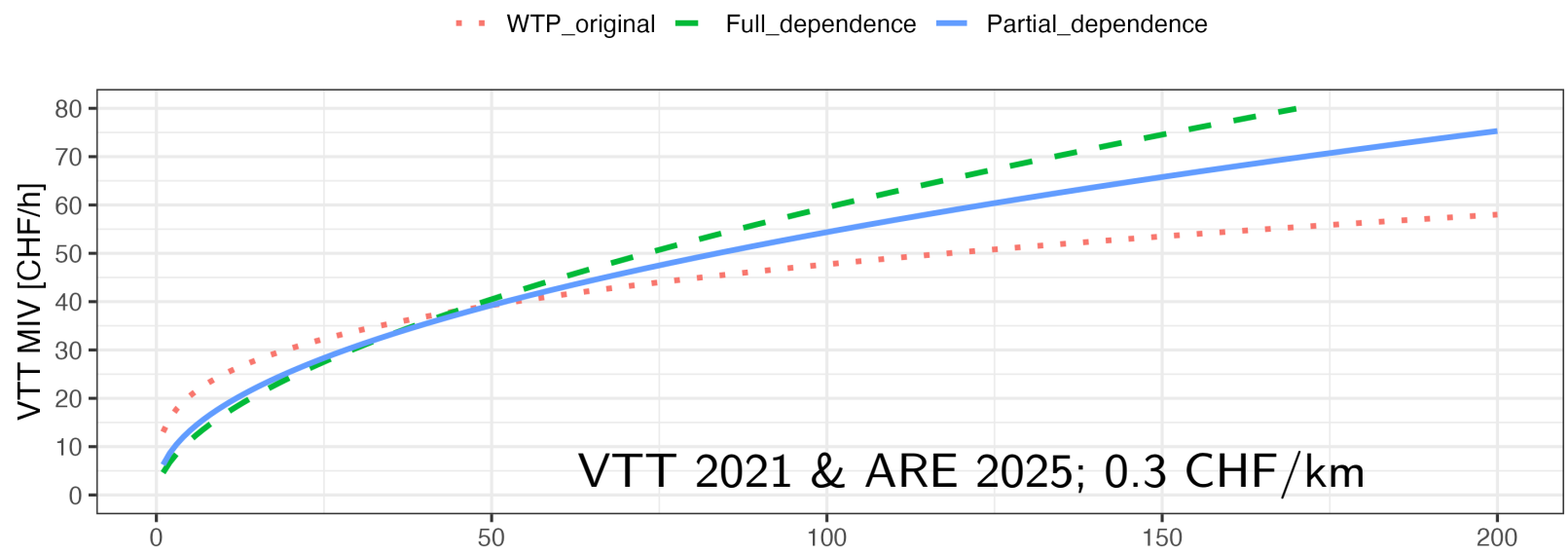
- **PT route choice**: In all datasets lower model fit when accounting for full reference point dependence
- E.g. ARE 2025: $\widehat{\tau} = 0.09 \implies$ almost no ref. point dependence; indifferent btw. $\overline{c}$ and c_{ref}
- Behavioral explanation: Familiarity with PT ticket prices

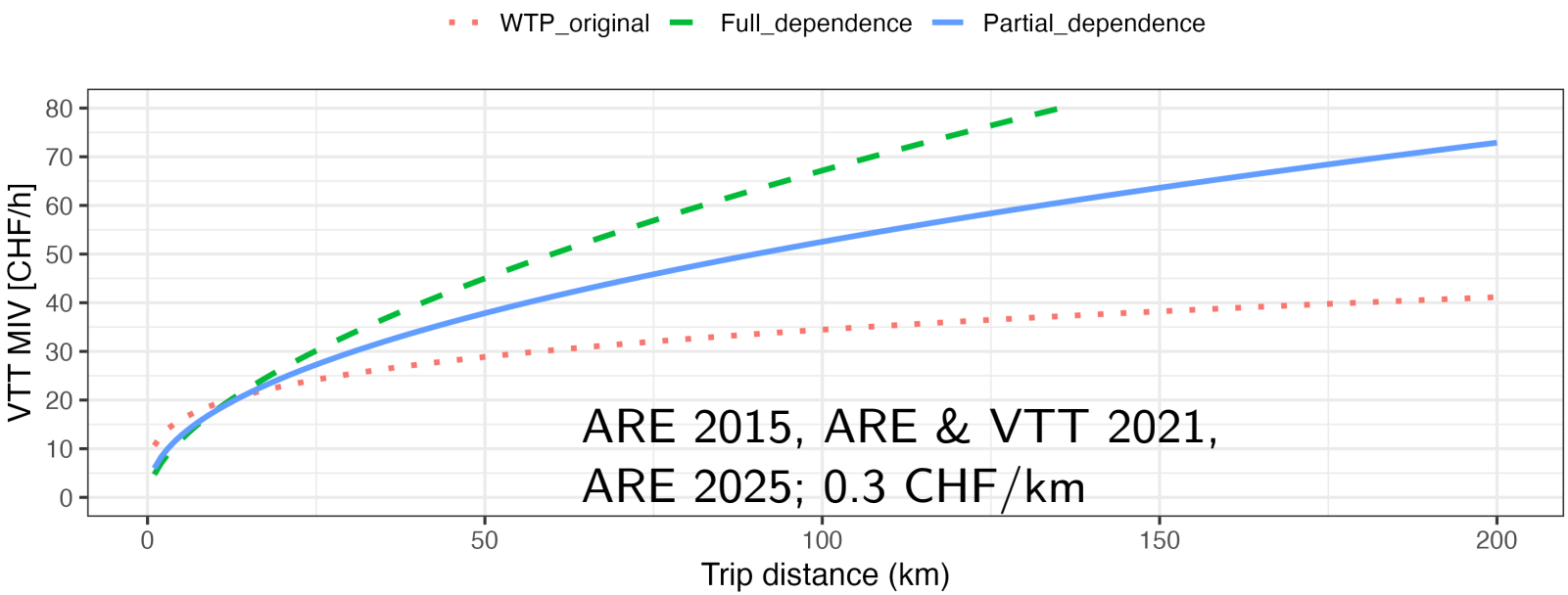
Results: Car route choice ($\tau = 1$)





Data pooling and VTT for MTMC 2015





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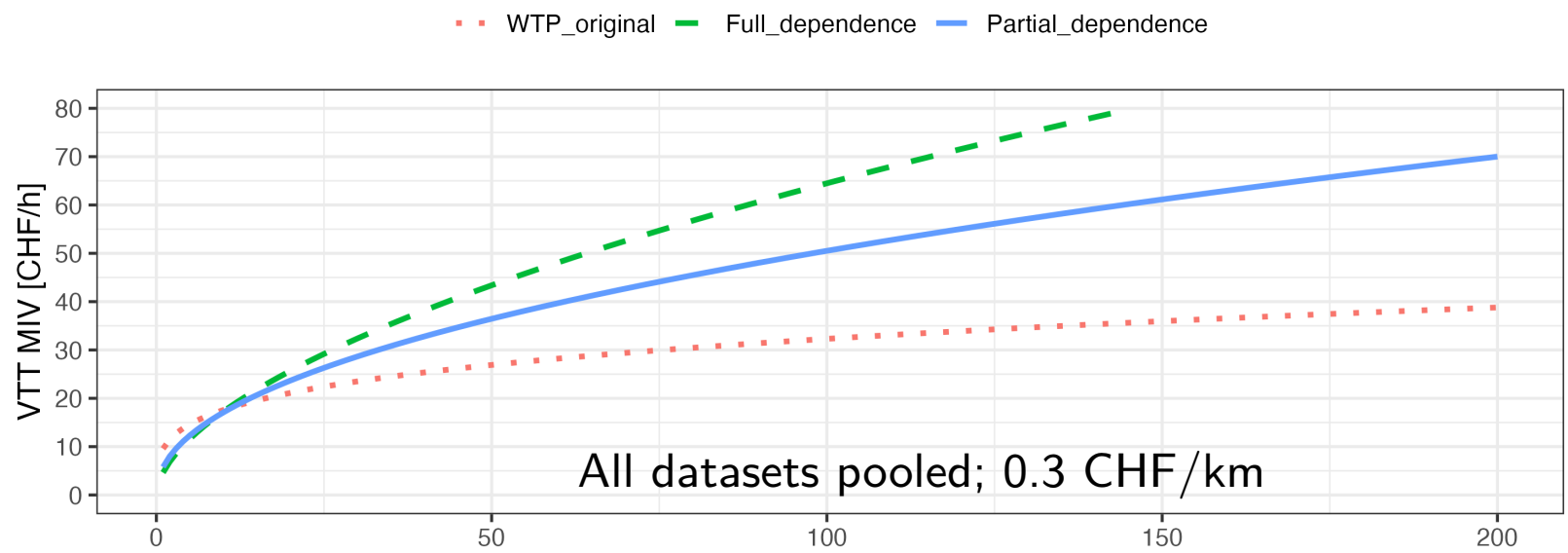

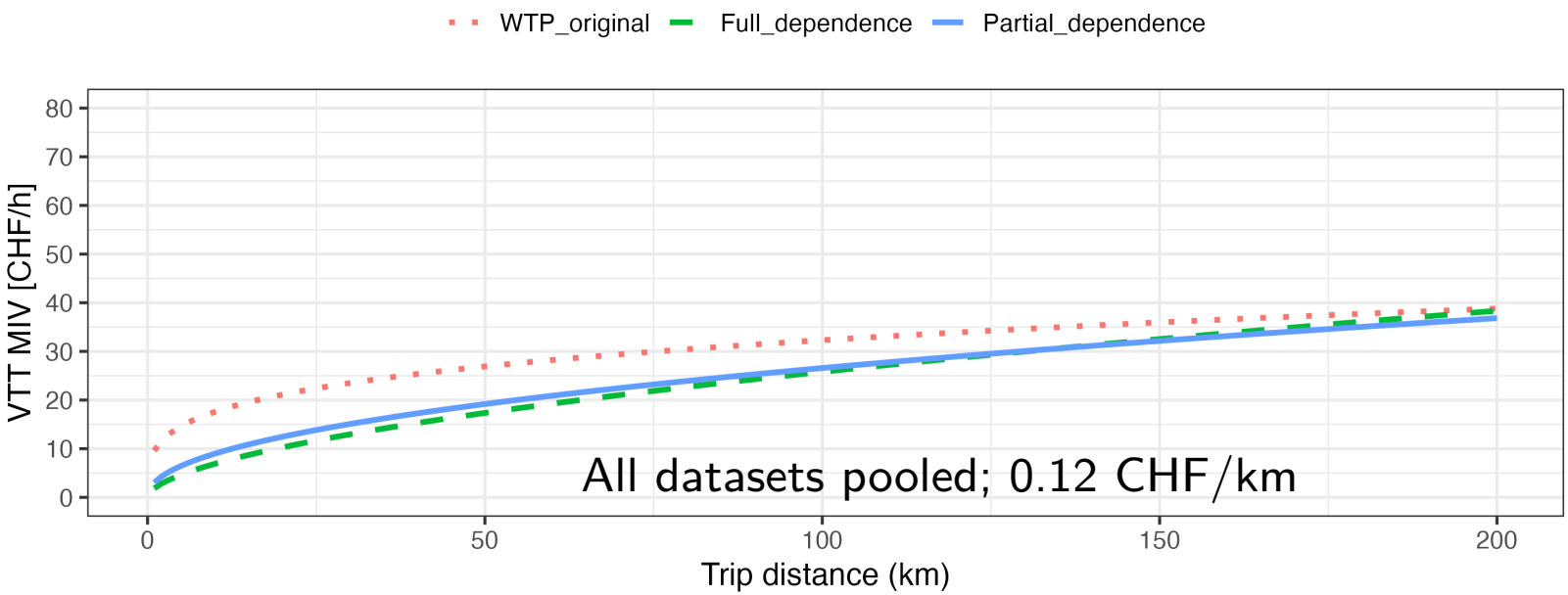

Results: Final models (all datasets pooled)

- Introducing partial dependence "increases" the baseline VTT
- Standard error increases over-proportionally (due to high correlations between β^{tt}, τ and λ^{tt})

	WTP	**Full dep.**	**Part. dep.**	**SignSize**
β^{scale}	1.64^{***}	1.80^{***}	1.83^{***}	1.79^{***}
λ^{scale}	0.13^{***}	0.10^{***}	0.12^{***}	0.12^{***}
μ^{mp}	-0.13^{***}	-0.30^{***}	-0.25^{***}	-0.13^{***}
β^{tt}	17.73^{***}	3.73^{***}	6.13^{***}	5.89^{***}
	(0.32)	(0.05)	(0.22)	(0.20)
λ^{tt}	0.26^{***}	-0.43^{***}	-0.21^{***}	-0.22^{***}
λ^{inc}	0.49^{***}	0.37^{***}	0.38^{***}	0.35^{***}
τ		1.00(fixed)	0.67^{***}	0.67^{***}
			(0.02)	(0.02)
ϑ^{sign+}				0.10^{***}
$\vartheta^{size,tt}$				-1.83^{***}
$\vartheta^{size,tc}$				-0.20
Number of parameters	16	16	17	20
Number of respondents	11606	11606	11606	11606
Number of choice observations	73622	73622	73622	73622
$\mathcal{LL}(0)$	-54683.52	-54683.52	-54683.52	-54683.52
$\mathcal{LL}(model)$	-39341.83	-38665.56	-38392.43	-38269.74
BIC	78862.98	77510.43	76975.38	76763.62

Conclusions

- Weighted average car VTT (MTMC 2015: 0.3 CHF/km): **28.9 CHF/h** (**23.1 CHF/h** with original WTP specification)
- **Reference dependent model helps to disentangle** (intertemporal) preferences from actual cost levels
- **Reference point shifts** with the actual cost level (dampened), indicating strong reference dependent behavior
- **No such behavioral pattern found for PT!**
- Next steps:
  - sociodemographics, trip purpose, random heterogeneity
  - develop method for pooled RP/SP (incl. mode choice) comparison
  - wait for the MTMC 2025 ...

Questions?