Analysis of the impact of travellers' attitudes and perceptions on mode choice in low-density areas

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Introduction

Aim: Infer mode choice from travellers' attitudes and perceptions

Introduction

Motivation: Mode choice often explained by quantitative attributes

- Cost
- Time
- etc.

Wish to measure impact of qualitative attributes as well

- Attitudes (against public transports, pro environment, pro high density, etc.)
- Perceptions (of car, public transports, etc.)

The survey

- Survey performed together with PostBus (leading bus company in Switzerland)
- Study in 3 phases
  - Qualitative survey (GPS data, trip diary, interviews)
  - Revealed preferences (RP) survey
  - Stated preferences (SP) survey

The survey

Qualitative survey: Design of quantitative surveys

RP survey: Respondants asked to describe

- All trips of particular day
- Opinions
- Habits
- Socio-economic information

SP survey: Respondants asked to choose between current transport mode and new service

The survey

Qualitative survey: Design of quantitative surveys

RP survey: Respondants asked to describe

- All trips of particular day
- Opinions
- Habits
- Socio-economic information

SP survey: Respondants asked to choose between current transport mode and new service

Analysis based on RP survey

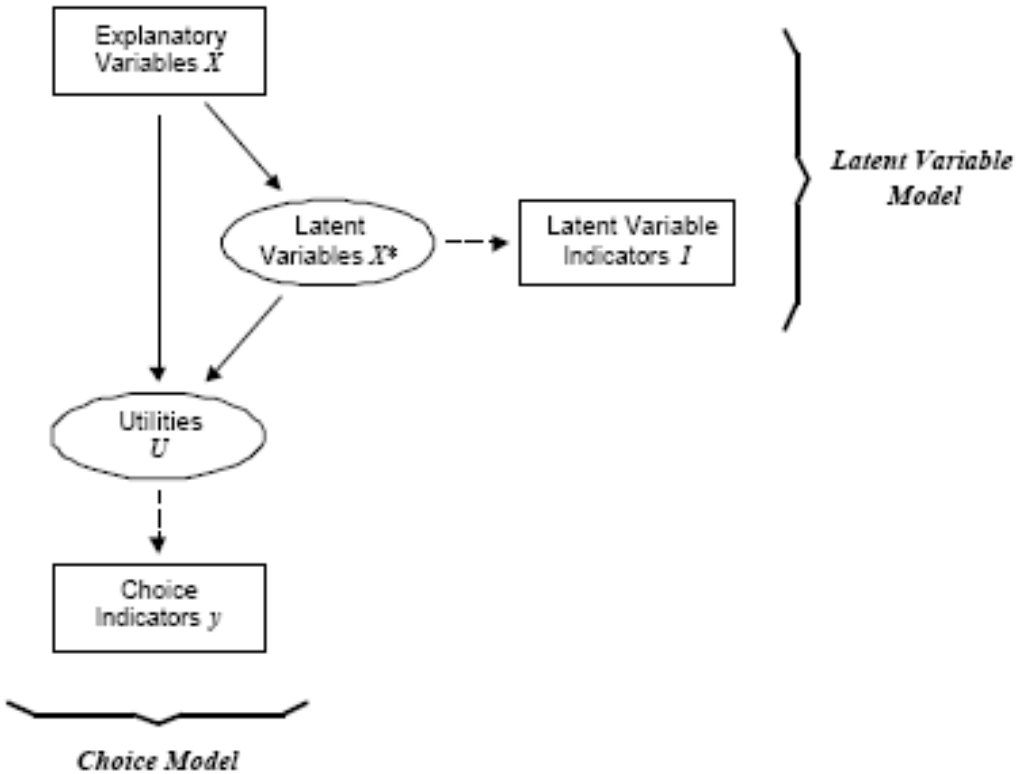
Methodology

- Factor analysis
- Integrated choice and latent variable model (Walker, 2001)

Methodology: Factor analysis

- Identification of latent variables
  - Attitude against public transports
  - Environmental concern
  - Public transport awareness
  - Status seeking behaviour
  - Attitude pro high density
  - Appreciation of a personnalised service
- Purpose: integrate latent variables in discrete choice model

Methodology: integrated choice and latent variable model



Methodology: integrated choice and latent variable model

- Structural equations:

  Choice model: $U_n = V(X_n, X_n^*; \beta) + \varepsilon_n \qquad \varepsilon_n \sim D(0, \Sigma_\varepsilon)$

  Latent variable model:

  $$X_n^* = h(X_n; \lambda) + \omega_n \qquad \omega_n \sim D(0, \Sigma_\omega)$$

- Measurement equations:

  $I_n = m(X_n, X_n^*; \alpha) + \nu_n \qquad \nu_n \sim D(0, \Sigma_\nu)$

Methodology: integrated choice and latent variable model

- Simultaneous estimation of choice and latent variable model
- Maximum likelihood:
  $f_4(y_n, I_n|X_n; \alpha, \beta, \lambda, \Sigma_\varepsilon, \Sigma_\nu, \Sigma_\omega) =$
  $\int_{X^*} P(y_n|X_n, X^*; \beta, \Sigma_\varepsilon) \cdot f_3(I_n|X_n, X^*; \alpha, \Sigma_\nu) \cdot f_1(X^*|X_n; \lambda, \Sigma_\omega) dX^*$

Methodology: integrated choice and latent variable model

Two models:

Modelling attitudes: Model with 2 latent attributes

- Attitude against public transports
- Environmental concern

Modelling perception: Model with one latent attribute

- Travellers' image of the car

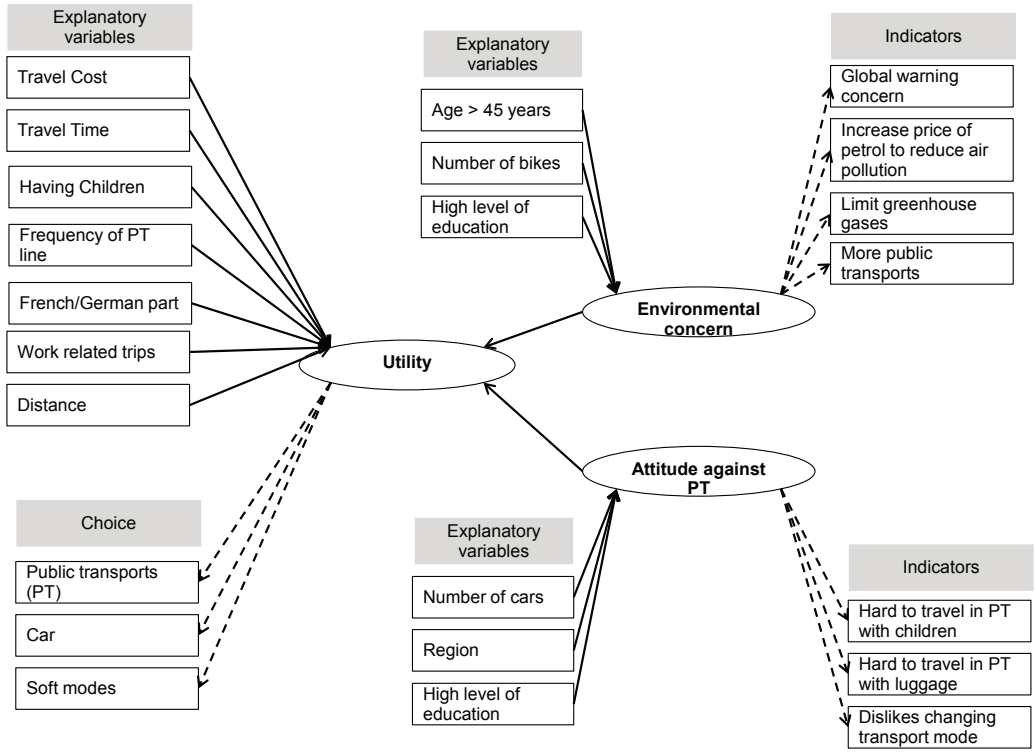
Methodology: integrated choice and latent variable model

Modelling attitudes: indicators for measurement equations

- Survey: respondant has to give opinion on sentence.
- Example:
  - 'It's hard to take public transports when I have luggages.'
- Rating scale:
  - $--$ total disagreement (coded 1)
  - $-$ disagreement (coded 2)
  - 0 neutral (coded 3)
  - $+$ agreement (coded 4)
  - $++$ total agreement (coded 5)

Methodology: integrated choice and latent variable model

Modelling attitudes: integrated framework



Methodology: integrated choice and latent variable model

Modelling perception: indicators for measurement equations

- Survey: respondant has to give 3 adjectives describing car
  - comfortable
  - polluting
  - useful
  - expensive
  - etc.

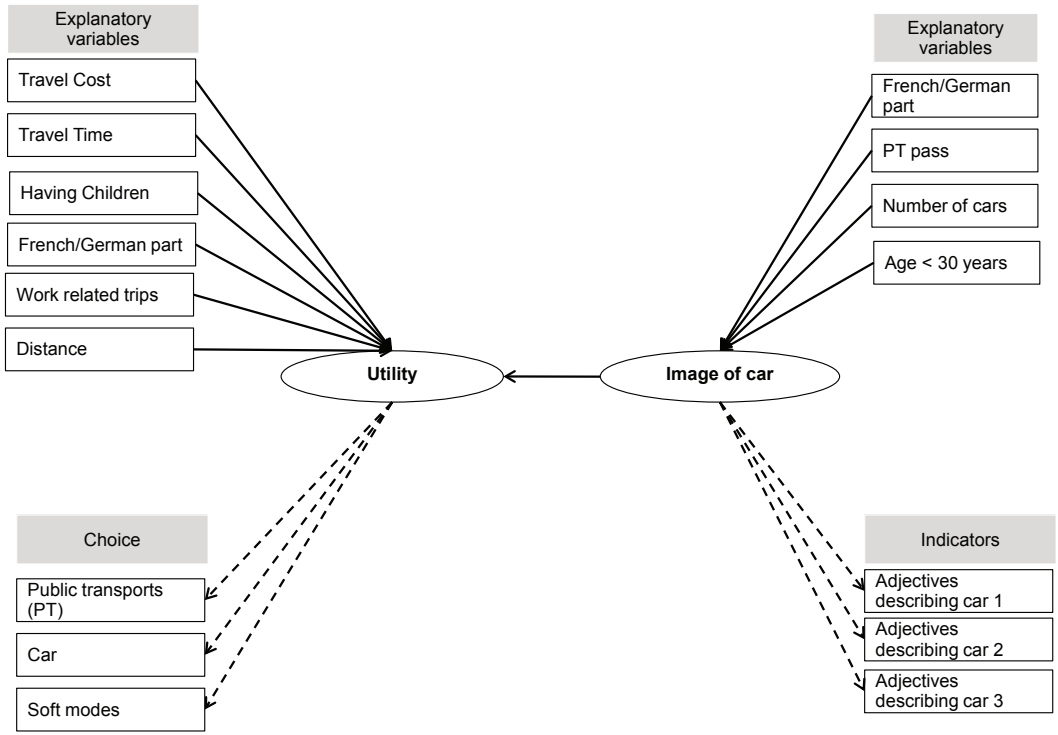
Methodology: integrated choice and latent variable model

Modelling perception: indicators for measurement equations

- Adjectives classified into 3 groups
  - positive connotation
  - neutral connotation
  - negative connotation
- Examples
  - flexible $\Longrightarrow +$ (coded 1)
  - necessary $\Longrightarrow 0$ (coded 0)
  - stressful $\Longrightarrow -$ (coded -1)

Methodology: integrated choice and latent variable model

Modelling perception: integrated framework



Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
$\mathrm{ASC}_{\mathrm{CAR}}$	0.16	0.93	0.17	0.87
$\mathrm{ASC}_{\mathrm{SM}}$	-0.41	0.97	-0.42	0.67
β_{AttEnv}	0.33	0.16	2.00	0.05
β_{AttPT}	-0.63	0.19	-3.28	0.00
$\beta_{\mathrm{children}}$	0.49	0.16	3.00	0.00
β_{cost}	-0.05	0.01	-6.23	0.00
$\beta_{\mathrm{distance}}$	-0.22	0.03	-6.99	0.00
$\beta_{\mathrm{frequency}}$	0.65	0.20	3.19	0.00
β_{work}	-0.61	0.15	-3.96	0.00
β_{french}	1.05	0.18	5.73	0.00
$\beta_{\mathrm{time_{car}}}$	-0.02	0.00	-6.53	0.00
$\beta_{\mathrm{time_{PT}}}$	-0.01	0.00	-4.47	0.00

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β_{work}	-0.61	0.15	-3.96	0.00
β_{french}	1.05	0.18	5.73	0.00
$\beta_{\mathrm{time_{car}}}$	-0.02	0.00	-6.53	0.00
$\beta_{\mathrm{time_{PT}}}$	-0.01	0.00	-4.47	0.00

Environmental concern positively correlated with choice of PT.

Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
$\mathrm{ASC}_{\mathrm{CAR}}$	0.16	0.93	0.17	0.87
$\mathrm{ASC}_{\mathrm{SM}}$	-0.41	0.97	-0.42	0.67
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β_{french}	1.05	0.18	5.73	0.00
$\beta_{\mathrm{time_{car}}}$	-0.02	0.00	-6.53	0.00
$\beta_{\mathrm{time_{PT}}}$	-0.01	0.00	-4.47	0.00

Attitude against PT negatively correlated with choice of PT.

Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
$\mathrm{ASC}_{\mathrm{CAR}}$	0.16	0.93	0.17	0.87
$\mathrm{ASC}_{\mathrm{SM}}$	-0.41	0.97	-0.42	0.67
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β_{french}	1.05	0.18	5.73	0.00
$\beta_{\mathrm{time_{car}}}$	-0.02	0.00	-6.53	0.00
$\beta_{\mathrm{time_{PT}}}$	-0.01	0.00	-4.47	0.00

Presence of children positively correlated with choice of car.

Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
$\mathrm{ASC}_{\mathrm{CAR}}$	0.16	0.93	0.17	0.87
$\mathrm{ASC}_{\mathrm{SM}}$	-0.41	0.97	-0.42	0.67
β_{AttEnv}	0.33	0.16	2.00	0.05
β_{AttPT}	-0.63	0.19	-3.28	0.00
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β_{french}	1.05	0.18	5.73	0.00
$\beta_{\mathrm{time_{car}}}$	-0.02	0.00	-6.53	0.00
$\beta_{\mathrm{time_{PT}}}$	-0.01	0.00	-4.47	0.00

Cost negatively correlated with choice of car and public transports.

Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
$\mathrm{ASC}_{\mathrm{CAR}}$	0.16	0.93	0.17	0.87
$\mathrm{ASC}_{\mathrm{SM}}$	-0.41	0.97	-0.42	0.67
β_{AttEnv}	0.33	0.16	2.00	0.05
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$\beta_{\mathrm{distance}}$	-0.22	0.03	-6.99	0.00
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β_{work}	-0.61	0.15	-3.96	0.00
β_{french}	1.05	0.18	5.73	0.00
$\beta_{\mathrm{time_{car}}}$	-0.02	0.00	-6.53	0.00
$\beta_{\mathrm{time_{PT}}}$	-0.01	0.00	-4.47	0.00

Distance negatively correlated with choice of soft modes.

Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
$\mathrm{ASC_{CAR}}$	0.16	0.93	0.17	0.87
$\mathrm{ASC_{SM}}$	-0.41	0.97	-0.42	0.67
β_{AttEnv}	0.33	0.16	2.00	0.05
β_{AttPT}	-0.63	0.19	-3.28	0.00
$\beta_{\mathrm{children}}$	0.49	0.16	3.00	0.00
β_{cost}	-0.05	0.01	-6.23	0.00
$\beta_{\mathrm{distance}}$	-0.22	0.03	-6.99	0.00
$\beta_{\mathrm{frequency}}$	0.65	0.20	3.19	0.00
β_{work}	-0.61	0.15	-3.96	0.00
β_{french}	1.05	0.18	5.73	0.00
$\beta_{\mathrm{time_{car}}}$	-0.02	0.00	-6.53	0.00
$\beta_{\mathrm{time_{PT}}}$	-0.01	0.00	-4.47	0.00

Frequency positively correlated with choice of public transports.

Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
$\mathrm{ASC}_{\mathrm{CAR}}$	0.16	0.93	0.17	0.87
$\mathrm{ASC}_{\mathrm{SM}}$	-0.41	0.97	-0.42	0.67
β_{AttEnv}	0.33	0.16	2.00	0.05
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$\beta_{\mathrm{children}}$	0.49	0.16	3.00	0.00
β_{cost}	-0.05	0.01	-6.23	0.00
$\beta_{\mathrm{distance}}$	-0.22	0.03	-6.99	0.00
$\beta_{\mathrm{frequency}}$	0.65	0.20	3.19	0.00
β_{work}	-0.61	0.15	-3.96	0.00
β_{french}	1.05	0.18	5.73	0.00
$\beta_{\mathrm{time_{car}}}$	-0.02	0.00	-6.53	0.00
$\beta_{\mathrm{time_{PT}}}$	-0.01	0.00	-4.47	0.00

Work related trips negatively correlated with choice of car.

Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
$\mathrm{ASC}_{\mathrm{CAR}}$	0.16	0.93	0.17	0.87
$\mathrm{ASC}_{\mathrm{SM}}$	-0.41	0.97	-0.42	0.67
β_{AttEnv}	0.33	0.16	2.00	0.05
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$\beta_{\mathrm{time_{car}}}$	-0.02	0.00	-6.53	0.00
$\beta_{\mathrm{time_{PT}}}$	-0.01	0.00	-4.47	0.00

French-speaking part positively correlated with choice of car.

Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
$\mathrm{ASC}_{\mathrm{CAR}}$	0.16	0.93	0.17	0.87
$\mathrm{ASC}_{\mathrm{SM}}$	-0.41	0.97	-0.42	0.67
β_{AttEnv}	0.33	0.16	2.00	0.05
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$\beta_{\mathrm{distance}}$	-0.22	0.03	-6.99	0.00
$\beta_{\mathrm{frequency}}$	0.65	0.20	3.19	0.00
β_{work}	-0.61	0.15	-3.96	0.00
β_{french}	1.05	0.18	5.73	0.00
$\beta_{\mathrm{time_{car}}}$	-0.02	0.00	-6.53	0.00
$\beta_{\mathrm{time_{PT}}}$	-0.01	0.00	-4.47	0.00

Time negatively correlated with choice of PT and car.
Effect greater for choice of car.

Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
α_2	1.24	0.26	4.81	0.00
α_3	0.85	0.32	2.66	0.01
b_{cars}	0.13	0.03	3.70	0.00
$b_{\text{HighEducation}}$	0.26	0.04	6.85	0.00
λ_2	0.73	0.09	8.40	0.00
λ_3	0.97	0.11	9.12	0.00
$b_{\text{meanAttPT}}$	3.04	0.08	38.60	0.00
b_{Basel}	-0.31	0.07	-4.17	0.00
$b_{\text{Graubuenden}}$	-0.23	0.12	-1.87	0.06
b_{EastCH}	-0.32	0.09	-3.33	0.00
b_{Valais}	-0.19	0.08	-2.47	0.01
b_{Bern}	-0.47	0.14	-3.24	0.00
σ_1	-0.47	0.07	-6.89	0.00
σ_{11}	-0.26	0.04	-5.71	0.00
σ_{12}	0.02	0.03	0.67	0.51
σ_{13}	-0.13	0.04	-3.53	0.00

Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
α_2	1.24	0.26	4.81	0.00
α_3	0.85	0.32	2.66	0.01
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$b_{\text{HighEducation}}$	0.26	0.04	6.85	0.00
λ_2	0.73	0.09	8.40	0.00
λ_3	0.97	0.11	9.12	0.00
$b_{\text{meanAttPT}}$	3.04	0.08	38.60	0.00
b_{Basel}	-0.31	0.07	-4.17	0.00
$b_{\text{Graubuenden}}$	-0.23	0.12	-1.87	0.06
b_{EastCH}	-0.32	0.09	-3.33	0.00
b_{Valais}	-0.19	0.08	-2.47	0.01
b_{Bern}	-0.47	0.14	-3.24	0.00
σ_1	-0.47	0.07	-6.89	0.00
σ_{11}	-0.26	0.04	-5.71	0.00
σ_{12}	0.02	0.03	0.67	0.51
σ_{13}	-0.13	0.04	-3.53	0.00

Number of cars positively correlated with attitude against PT.

Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
α_2	1.24	0.26	4.81	0.00
α_3	0.85	0.32	2.66	0.01
b_{cars}	0.13	0.03	3.70	0.00
$b_{\text{HighEducation}}$	0.26	0.04	6.85	0.00
λ_2	0.73	0.09	8.40	0.00
λ_3	0.97	0.11	9.12	0.00
$b_{\text{meanAttPT}}$	3.04	0.08	38.60	0.00
b_{Basel}	-0.31	0.07	-4.17	0.00
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b_{EastCH}	-0.32	0.09	-3.33	0.00
b_{Valais}	-0.19	0.08	-2.47	0.01
b_{Bern}	-0.47	0.14	-3.24	0.00
σ_1	-0.47	0.07	-6.89	0.00
σ_{11}	-0.26	0.04	-5.71	0.00
σ_{12}	0.02	0.03	0.67	0.51
σ_{13}	-0.13	0.04	-3.53	0.00

High education negatively correlated with attitude against PT (negative sign in the regression equation).

Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
α_2	1.24	0.26	4.81	0.00
α_3	0.85	0.32	2.66	0.01
b_{cars}	0.13	0.03	3.70	0.00
$b_{\text{HighEducation}}$	0.26	0.04	6.85	0.00
λ_2	0.73	0.09	8.40	0.00
λ_3	0.97	0.11	9.12	0.00
$b_{\text{meanAttPT}}$	3.04	0.08	38.60	0.00
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b_{Valais}	-0.19	0.08	-2.47	0.01
b_{Bern}	-0.47	0.14	-3.24	0.00
σ_1	-0.47	0.07	-6.89	0.00
σ_{11}	-0.26	0.04	-5.71	0.00
σ_{12}	0.02	0.03	0.67	0.51
σ_{13}	-0.13	0.04	-3.53	0.00

German-speaking regions negatively correlated with attitude against PT.

Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
$b_{\text{age}>45}$	0.01	0.00	2.52	0.01
α_5	-1.77	0.42	-4.23	0.00
α_6	1.06	0.22	4.83	0.00
α_7	0.03	0.33	0.10	0.92
b_{bikes}	0.06	0.01	4.55	0.00
$b_{\text{HighEducation}}$	0.26	0.04	6.85	0.00
λ_5	1.17	0.11	10.53	0.00
λ_6	0.87	0.06	15.02	0.00
λ_7	0.90	0.09	10.35	0.00
$b_{\text{meanAttEnv}}$	3.45	0.06	59.19	0.00
σ_2	-0.49	0.06	-7.96	0.00
σ_21	-0.17	0.03	-5.76	0.00
σ_22	0.09	0.03	2.98	0.00
σ_23	-0.58	0.04	-15.13	0.00
σ_24	-0.01	0.03	-0.28	0.78

Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
$b_{\text{age}>45}$	0.01	0.00	2.52	0.01
α_5	-1.77	0.42	-4.23	0.00
α_6	1.06	0.22	4.83	0.00
α_7	0.03	0.33	0.10	0.92
b_{bikes}	0.06	0.01	4.55	0.00
$b_{\text{HighEducation}}$	0.26	0.04	6.85	0.00
λ_5	1.17	0.11	10.53	0.00
λ_6	0.87	0.06	15.02	0.00
λ_7	0.90	0.09	10.35	0.00
$b_{\text{meanAttEnv}}$	3.45	0.06	59.19	0.00
σ_2	-0.49	0.06	-7.96	0.00
σ_21	-0.17	0.03	-5.76	0.00
σ_22	0.09	0.03	2.98	0.00
σ_23	-0.58	0.04	-15.13	0.00
σ_24	-0.01	0.03	-0.28	0.78

People aged more than 45 are concerned by environment.

Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
$b_{\text{age}>45}$	0.01	0.00	2.52	0.01
α_5	-1.77	0.42	-4.23	0.00
α_6	1.06	0.22	4.83	0.00
α_7	0.03	0.33	0.10	0.92
b_{bikes}	0.06	0.01	4.55	0.00
$b_{\text{HighEducation}}$	0.26	0.04	6.85	0.00
λ_5	1.17	0.11	10.53	0.00
λ_6	0.87	0.06	15.02	0.00
λ_7	0.90	0.09	10.35	0.00
$b_{\text{meanAttEnv}}$	3.45	0.06	59.19	0.00
σ_2	-0.49	0.06	-7.96	0.00
σ_21	-0.17	0.03	-5.76	0.00
σ_22	0.09	0.03	2.98	0.00
σ_23	-0.58	0.04	-15.13	0.00
σ_24	-0.01	0.03	-0.28	0.78

Number of bikes in the household positively correlated with environmental concern.

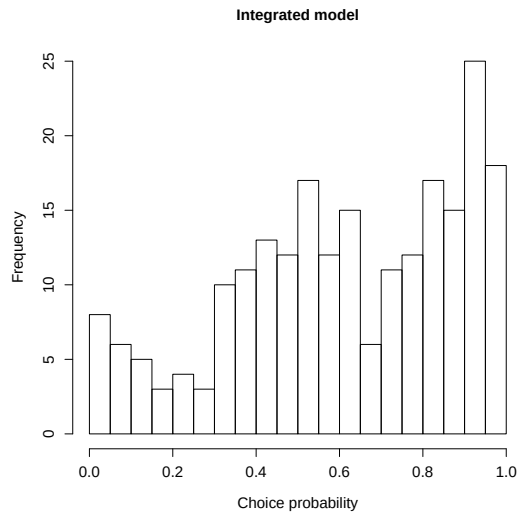
Results: modelling attitudes

Name	Value	Std Error	t-test	p-value
$b_{\text{age}>45}$	0.01	0.00	2.52	0.01
α_5	-1.77	0.42	-4.23	0.00
α_6	1.06	0.22	4.83	0.00
α_7	0.03	0.33	0.10	0.92
b_{bikes}	0.06	0.01	4.55	0.00
$b_{\text{HighEducation}}$	0.26	0.04	6.85	0.00
λ_5	1.17	0.11	10.53	0.00
λ_6	0.87	0.06	15.02	0.00
λ_7	0.90	0.09	10.35	0.00
$b_{\text{meanAttEnv}}$	3.45	0.06	59.19	0.00
σ_2	-0.49	0.06	-7.96	0.00
σ_21	-0.17	0.03	-5.76	0.00
σ_22	0.09	0.03	2.98	0.00
σ_23	-0.58	0.04	-15.13	0.00
σ_24	-0.01	0.03	-0.28	0.78

High level of education positively correlated with environmental concern.

Results: modelling attitudes

Validation of the data: histograms of choice probabilities for 20% of the respondants



Simultaneous estimation of parameters by maximum likelihood

- 66% of choice probabilities > 0.5
- 19% of choice probabilities > 0.9

Results: modelling perception

Name	Value	Std Error	t-test	p-value
$\mathrm{ASC}_{\mathrm{CAR}}$	-7.85	2.88	-2.73	0.01
$\mathrm{ASC}_{\mathrm{MD}}$	-0.08	0.30	-0.28	0.78
$\beta_{\mathrm{children}}$	0.27	0.20	1.32	0.19
β_{cost}	-0.04	0.01	-3.66	0.00
$\beta_{\mathrm{distance}}$	-0.23	0.03	-6.76	0.00
β_{work}	-0.79	0.20	-4.00	0.00
$\beta_{\mathrm{ImageCar}}$	1.79	0.32	5.51	0.00
β_{french}	3.02	0.40	7.49	0.00
$\beta_{\mathrm{time_{car}}}$	-0.02	0.00	-6.02	0.00
$\beta_{\mathrm{time_{PT}}}$	-0.01	0.00	-4.49	0.00

Results: modelling perception

Name	Value	Std Error	t-test	p-value
$\mathrm{ASC}_{\mathrm{CAR}}$	-7.85	2.88	-2.73	0.01
$\mathrm{ASC}_{\mathrm{MD}}$	-0.08	0.30	-0.28	0.78
$\beta_{\mathrm{children}}$	0.27	0.20	1.32	0.19
β_{cost}	-0.04	0.01	-3.66	0.00
$\beta_{\mathrm{distance}}$	-0.23	0.03	-6.76	0.00
β_{work}	-0.79	0.20	-4.00	0.00
$\beta_{\mathrm{ImageCar}}$	1.79	0.32	5.51	0.00
β_{french}	3.02	0.40	7.49	0.00
$\beta_{\mathrm{time_{car}}}$	-0.02	0.00	-6.02	0.00
$\beta_{\mathrm{time_{PT}}}$	-0.01	0.00	-4.49	0.00

Positive image of car increases choice of car.

Results: modelling perception

Name	Value	Std Error	t-test	p-value
b_{pass}	-1.00	0.16	-6.08	0.00
b_{actif}	0.20	0.10	2.07	0.04
b_{student}	-1.05	0.22	-4.75	0.00
$b_{\text{meanImageCar}}$	3.85	1.19	3.23	0.00
b_{german}	0.94	0.18	5.30	0.00
σ	-0.57	0.23	-2.49	0.01
b_{cars}	0.44	0.08	5.27	0.00
δ_1	0.28	0.03	10.92	0.00
λ_2	0.78	0.07	11.05	0.00
λ_3	0.53	0.13	4.11	0.00
τ_1	1.86	1.16	1.60	0.11

Results: modelling perception

Name	Value	Std Error	t-test	p-value
b_{pass}	-1.00	0.16	-6.08	0.00
b_{actif}	0.20	0.10	2.07	0.04
b_{student}	-1.05	0.22	-4.75	0.00
$b_{\text{meanImageCar}}$	3.85	1.19	3.23	0.00
b_{german}	0.94	0.18	5.30	0.00
σ	-0.57	0.23	-2.49	0.01
b_{cars}	0.44	0.08	5.27	0.00
δ_1	0.28	0.03	10.92	0.00
λ_2	0.78	0.07	11.05	0.00
λ_3	0.53	0.13	4.11	0.00
τ_1	1.86	1.16	1.60	0.11

Possession of a pass negatively correlated with good image of car.

Results: modelling perception

Name	Value	Std Error	t-test	p-value
b_{pass}	-1.00	0.16	-6.08	0.00
b_{actif}	0.20	0.10	2.07	0.04
b_{student}	-1.05	0.22	-4.75	0.00
$b_{\text{meanImageCar}}$	3.85	1.19	3.23	0.00
b_{german}	0.94	0.18	5.30	0.00
σ	-0.57	0.23	-2.49	0.01
b_{cars}	0.44	0.08	5.27	0.00
δ_1	0.28	0.03	10.92	0.00
λ_2	0.78	0.07	11.05	0.00
λ_3	0.53	0.13	4.11	0.00
τ_1	1.86	1.16	1.60	0.11

Job at 100% positively correlated with good image of car.

Results: modelling perception

Name	Value	Std Error	t-test	p-value
b_{pass}	-1.00	0.16	-6.08	0.00
b_{actif}	0.20	0.10	2.07	0.04
b_{student}	-1.05	0.22	-4.75	0.00
$b_{\text{meanImageCar}}$	3.85	1.19	3.23	0.00
b_{german}	0.94	0.18	5.30	0.00
σ	-0.57	0.23	-2.49	0.01
b_{cars}	0.44	0.08	5.27	0.00
δ_1	0.28	0.03	10.92	0.00
λ_2	0.78	0.07	11.05	0.00
λ_3	0.53	0.13	4.11	0.00
τ_1	1.86	1.16	1.60	0.11

Students have a negative image of the car.

Results: modelling perception

Name	Value	Std Error	t-test	p-value
b_{pass}	-1.00	0.16	-6.08	0.00
b_{actif}	0.20	0.10	2.07	0.04
b_{student}	-1.05	0.22	-4.75	0.00
$b_{\text{meanImageCar}}$	3.85	1.19	3.23	0.00
b_{german}	0.94	0.18	5.30	0.00
σ	-0.57	0.23	-2.49	0.01
b_{cars}	0.44	0.08	5.27	0.00
δ_1	0.28	0.03	10.92	0.00
λ_2	0.78	0.07	11.05	0.00
λ_3	0.53	0.13	4.11	0.00
τ_1	1.86	1.16	1.60	0.11

German part is positively correlated with good image of car.

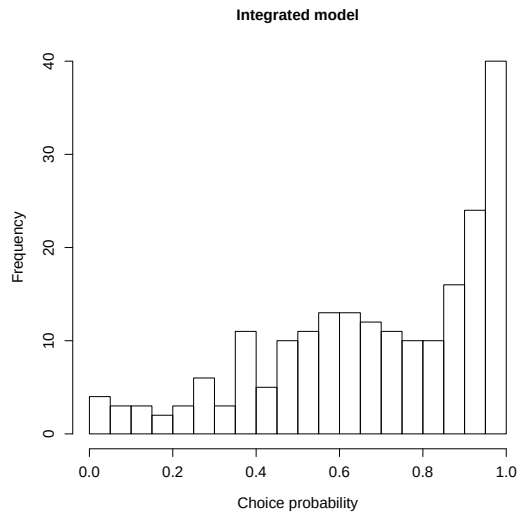
Results: modelling perception

Name	Value	Std Error	t-test	p-value
b_{pass}	-1.00	0.16	-6.08	0.00
b_{actif}	0.20	0.10	2.07	0.04
b_{student}	-1.05	0.22	-4.75	0.00
$b_{\text{meanImageCar}}$	3.85	1.19	3.23	0.00
b_{german}	0.94	0.18	5.30	0.00
σ	-0.57	0.23	-2.49	0.01
b_{cars}	0.44	0.08	5.27	0.00
δ_1	0.28	0.03	10.92	0.00
λ_2	0.78	0.07	11.05	0.00
λ_3	0.53	0.13	4.11	0.00
τ_1	1.86	1.16	1.60	0.11

Number of cars positively correlated with good image of car.

Results: modelling perception

Validation of the data: histograms of choice probabilities for 20% of the respondants



- 76% of choice probabilities > 0.5
- 30% of choice probabilities > 0.9

Further research

- Types of model enables determine population segments.
  - Further developement $\Longrightarrow$ latent class model.
- Include more than 2 latent variables.
- Combine both models.
- Model with perception of car
  - Classified adjectives into positive, neutral and negative connotation.
  - Capture other types of perceptions using adjectives.

Appendix

Appendix

Modelling attitudes: specification of the choice model

$$U_{\text{car}} = \text{ASC}_{\text{car}} + \beta_{\text{cost}} \cdot \text{cost}_{\text{car}} + \beta_{\text{work}} \cdot \text{work} + \beta_{\text{children}} \cdot \text{children} + \beta_{\text{french}} \cdot \text{french} + \beta_{\text{time}_{\text{car}}} \cdot \text{time}_{\text{car}} + \varepsilon_{\text{car}} \quad \text{with } \varepsilon_{\text{car}} \sim \text{Gumbel}(0, 1)$$

$$U_{\text{PT}} = \beta_{\text{cost}} \cdot \text{cost}_{\text{PT}} + \beta_{\text{time}_{\text{PT}}} \cdot \text{time}_{\text{PT}} + \beta_{\text{frequency}} \cdot \text{frequency} + \beta_{\text{AttPT}} \cdot \text{AttPT} + \beta_{\text{AttEnv}} \cdot \text{AttEnv} + \varepsilon_{\text{PT}} \quad \text{with } \varepsilon_{\text{PT}} \sim \text{Gumbel}(0, 1)$$

$$U_{\text{SM}} = \text{ASC}_{\text{SM}} + \beta_{\text{distance}} \cdot \text{distance} + \varepsilon_{\text{SM}} \quad \text{with } \varepsilon_{\text{SM}} \sim \text{Gumbel}(0, 1)$$

Appendix

Modelling attitudes: specification of the structural equations

$$\begin{aligned}\text{AttPT} = b_{\text{meanAttPT}} &+ b_{\text{Basel}} \cdot \text{Basel} + b_{\text{Graubuenden}} \cdot \text{Graubuenden} + b_{\text{EastCH}} \cdot \text{EastCH} \\ &+ b_{\text{Valais}} \cdot \text{Valais} + b_{\text{Bern}} \cdot \text{Bern} + b_{\text{cars}} \cdot \text{cars} \\ &+ b_{\text{HighEducation}} \cdot \text{HighEducation} + \sigma_1 \cdot \omega_{\text{AttPT}} \qquad \text{with } \omega_{\text{AttPT}} \sim N(0,1)\end{aligned}$$

$$\begin{aligned}\text{AttEnv} = b_{\text{meanAttEnv}} &+ b_{\text{age}>45} \cdot \text{age}>45 + b_{\text{bikes}} \cdot \text{bikes} + b_{\text{HighEducation}} \cdot \text{HighEducation} \\ &+ \sigma_2 \cdot \omega_{\text{AttEnv}} \qquad \text{with } \omega_{\text{AttEnv}} \sim N(0,1)\end{aligned}$$

Appendix

Modelling attitudes: specification of the measurement equations

$$I_{\text{children}} = \text{AttPT} + \sigma_{\mathbf{1}}\mathbf{1} \cdot \omega_{\text{children}} \quad \text{with } \omega_{\text{children}} \sim N(0,1)$$

$$I_{\text{change}} = \text{AttPT} + \sigma_{\mathbf{1}}\mathbf{2} \cdot \omega_{\text{change}} \quad \text{with } \omega_{\text{change}} \sim N(0,1)$$

$$I_{\text{luggage}} = \text{AttPT} + \sigma_{\mathbf{1}}\mathbf{3} \cdot \omega_{\text{luggage}} \quad \text{with } \omega_{\text{luggage}} \sim N(0,1)$$

Appendix

Modelling perception: specification of the choice model

$$U_{\text{car}} = \text{ASC}_{\text{car}} + \beta_{\text{cost}} \cdot \text{cost}_{\text{car}} + \beta_{\text{work}} \cdot \text{work} + \beta_{\text{children}} \cdot \text{children} + \beta_{\text{french}} \cdot \text{french} + \beta_{\text{time}_{\text{car}}} \cdot \text{time}_{\text{car}} + \beta_{\text{ImageCar}} \cdot \text{ImageCar} + \varepsilon_{\text{car}} \quad \text{with } \varepsilon_{\text{car}} \sim \text{Gumbel}(0, 1)$$

$$U_{\text{PT}} = \beta_{\text{cost}} \cdot \text{cost}_{\text{PT}} + \beta_{\text{time}_{\text{PT}}} \cdot \text{time}_{\text{PT}} + \varepsilon_{\text{PT}} \quad \text{with } \varepsilon_{\text{PT}} \sim \text{Gumbel}(0, 1)$$

$$U_{\text{SM}} = \text{ASC}_{\text{SM}} + \beta_{\text{distance}} \cdot \text{distance} + \varepsilon_{\text{SM}} \quad \text{with } \varepsilon_{\text{SM}} \sim \text{Gumbel}(0, 1)$$

Appendix

Modelling perception: specification of the structural equation

$$\begin{aligned}\text{ImageCar} = b_{\text{meanImageCar}} \quad &+ \quad b_{\text{german}} \cdot \text{german} + b_{\text{pass}} \cdot \text{pass} + b_{\text{cars}} \cdot \text{cars} + b_{\text{actif}} \cdot \text{actif} \\ &+ \quad b_{\text{student}} \cdot \text{student} + \sigma \cdot \omega \qquad \text{with } \omega \sim N(0,1)\end{aligned}$$

Appendix

Modelling perception: specification of the measurement equations

$I_1 = \text{ImageCar} + \nu_1 \qquad \text{with } \nu_1 \sim \text{Logistic}(0, 1)$

$I_2 = \lambda_2 \cdot \text{ImageCar} + \nu_2 \qquad \text{with } \nu_2 \sim \text{Logistic}(0, 1)$

$I_3 = \lambda_3 \cdot \text{ImageCar} + \nu_3 \qquad \text{with } \nu_3 \sim \text{Logistic}(0, 1)$