Data collection methods and models for consumer choice behaviour: Examples from the transport sector

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Motivation

Calculation of equilibrium points after some policy change using

\[ k = f(d(k, M, P), I, S) \]

with

Demand model \( d = g(k, M, P) \) and
Supply model \( k = f(d, I, S) \)

<table>
<thead>
<tr>
<th>k</th>
<th>Generalised costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>Market structure</td>
</tr>
<tr>
<td>I</td>
<td>Infrastructure</td>
</tr>
<tr>
<td>d</td>
<td>Demand</td>
</tr>
<tr>
<td>P</td>
<td>„Population“</td>
</tr>
<tr>
<td>S</td>
<td>Services</td>
</tr>
</tbody>
</table>
Motivation

Keeping market structure and population constant, we are searching for

\[ d = f(k) \]

or

\[ d_j = f(k_j) \]

\[ = f\left( \sum \beta_{j,q,t} x_{j,q,t} + \beta_{q,t} c_{q,t} x_{j,q,t} + \beta_{q,p} p_{q,p} x_{j,q,t} \right) \]
Focus

Discrete, disaggregate choices (for agent-based simulations)

Issues:

• data

• (one possible) statistical model form

• and an example
Types of data

Four classes:

• Properties of the person $q$ and context $(p_q)$

• Revealed behaviour $(d_j)$, description of the alternative $(x_{j,q,t})$ and its choice context $(c_{q,t})$

• Stated responses in hypothetical markets

• Attitudes, beliefs and values
## Stated response surveys (adapted from Lee-Gosselin)

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Values of context variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Given</td>
<td>Stated preference</td>
</tr>
<tr>
<td></td>
<td>(Stated choice)</td>
</tr>
<tr>
<td></td>
<td>(Trade-off between</td>
</tr>
<tr>
<td></td>
<td>alternatives)</td>
</tr>
<tr>
<td>Not given</td>
<td>Stated adaptation</td>
</tr>
<tr>
<td></td>
<td>(Constructing</td>
</tr>
<tr>
<td></td>
<td>alternatives)</td>
</tr>
</tbody>
</table>

Stated tolerance
(Transfer price)
(Switch in alternatives)
Observing choices, contexts and markets

Based on our hypothesis about the variables influencing we obtain:

In revealed preference (RP) surveys:

• 1 to 3 or 4 choices without (much) control over the context variables

In stated preference (SP) surveys:

• 12-15 (and more) choices with full control over the context variables
RP: Plus and minus

Plus:
• It has happened
• Reflects current market situation

Minus:
• Not all information is available for the analyst (incomplete hypotheses before the data collection)
• Often strong correlations between variables of interest
• Too small variance of the variables of interest
• The effects of some variables of interest are too weak to be identified in the typical survey
• Difficulties in imputing the variables describing the non-chosen alternatives
SP: Plus and Minus

Plus:
- Full control over size, structure and values of the variance-covariance matrix
- Choice of variables (weak and strong)
- All information which the respondent uses is known

Minus:
- It has not happened in real life
- Inertia effects
- Limits on the number of variables
- Framing effects
Current best practise in SP construction

- Clear hypothesis
- Clear a-priori market segmentation
- Clear definition of the choice context

- Recruitment from RP surveys
- Construction of SP around an observed choice
- Efficient factorial designs
- Limit the number of experiments to 12-15 relevant ones (of two, three types) involving up to 10 variables across alternatives
- Attention to the distribution of the trade-offs offered
- Hierarchical sets of experiments for very complex choice situations
**Example: stated preference**

<table>
<thead>
<tr>
<th>Ihr Busangebot</th>
<th>Wie beurteilen Sie dieses Angebot?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reisezeit:</td>
<td>30 min</td>
</tr>
<tr>
<td>Fahrkomfort:</td>
<td>gut</td>
</tr>
<tr>
<td>Takt:</td>
<td>alle 15 min</td>
</tr>
<tr>
<td>Zuverlässigkeit:</td>
<td>gut</td>
</tr>
</tbody>
</table>
**Example: stated choice**

<table>
<thead>
<tr>
<th>Möglichkeit 1</th>
<th>Möglichkeit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sie fahren mit dem Auto</strong></td>
<td><strong>Sie fahren mit dem Zug</strong></td>
</tr>
<tr>
<td>Fahrzeit (Tür zu Tür) : 35 Minuten</td>
<td>Zugangszeit (von zu Hause/Ausgangsort zum Bahnhof): 15 Minuten</td>
</tr>
<tr>
<td>Fahrzeit (Zeit im System) : 20 Minuten</td>
<td>Umsteigen: 2 mal</td>
</tr>
<tr>
<td>Intervall (Fahrplantaakt): 15 Minuten</td>
<td>Intervall (Fahrplantaakt): 15 Minuten</td>
</tr>
<tr>
<td>Komfort: ICN</td>
<td>Komfort: ICN</td>
</tr>
<tr>
<td>Preis (Reisekosten): 5 Fr.</td>
<td>Preis (Reisekosten): 6 Fr.</td>
</tr>
<tr>
<td>Wahrscheinlichkeit für eine mindestens 10-Min. Verspätung ist: 20%</td>
<td>Wahrscheinlichkeit für eine mindestens 10-Min. Verspätung ist: 5%</td>
</tr>
</tbody>
</table>

Ihre Wahl ?

---

Example: *stated choice*
Example: *stated-choice*

<table>
<thead>
<tr>
<th>Gegeben ist folgende Situation:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Öffentlicher Verkehr:</strong></td>
</tr>
<tr>
<td>Es fährt eine Strassenbahn</td>
</tr>
<tr>
<td>alle 6 min</td>
</tr>
<tr>
<td>in 0 von 10 Fällen unpünktlich</td>
</tr>
<tr>
<td>Fahrt dauert insgesamt 20 min</td>
</tr>
<tr>
<td>Fusswege von/zur Haltestelle dauern insgesamt 7 min</td>
</tr>
<tr>
<td>Fahrt mit der Strassenbahn kostet 2.50 DM</td>
</tr>
<tr>
<td><strong>Rad:</strong></td>
</tr>
<tr>
<td>Fussweg bis zum Rad 1 min</td>
</tr>
<tr>
<td>Fahrzeit mit dem Rad 8 min</td>
</tr>
<tr>
<td>Zum abstellen des Rades gibt es keinen Fahrradständer</td>
</tr>
<tr>
<td>Fussweg vom abgestellten Rad zum Ziel 1 min</td>
</tr>
<tr>
<td>Als Radweg ausgebaut sind 15 % der Strecke</td>
</tr>
<tr>
<td><strong>zu Fuss:</strong></td>
</tr>
<tr>
<td>Gehzeit ist 23 min</td>
</tr>
<tr>
<td><strong>Ihre Entscheidung wäre:</strong></td>
</tr>
<tr>
<td>Strassenbahn ___</td>
</tr>
<tr>
<td>Rad ___</td>
</tr>
<tr>
<td>zu Fuss ___</td>
</tr>
</tbody>
</table>
Example: *stated ranking*

<table>
<thead>
<tr>
<th>Preis</th>
<th>Umsteigen</th>
<th>Fahrtzeit</th>
<th>Zugang</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.50 DM</td>
<td>Nein</td>
<td>15 min</td>
<td>10 min</td>
</tr>
<tr>
<td>1.50 DM</td>
<td>Nein</td>
<td>20 min</td>
<td>20 min</td>
</tr>
<tr>
<td>2.25 DM</td>
<td>Einzel</td>
<td>15 min</td>
<td>8 min</td>
</tr>
</tbody>
</table>
Example: *stated ranking*
Modelling choices

Aggregate:
- Any suitable regression model
- Any suitable time-series model

Disaggregate:
- Random utility models
- Discriminant analysis
- SEM
- Classification trees
- Rule-based systems
General model

Separation of

- Knowledge and relevance of alternatives
- Choice among relevant alternatives

\[ P_q(i) = P_q(i \mid C) \cdot P_q(C \mid C^*) \]

\( P_q(j) \) Choice probability of alternative j by person q
\( P_q(j \mid C) \) Choice probability of alternative j by person q from the set of alternatives C
\( P_q(C \mid C^*) \) Choice probability of C by person q from the set of all sets of alternatives C*
Definition of the utility

We assume that the utility $U_{jq}$ of alternative $j$ for person $q$:

$$U_{jq} = U(X_{kjq}) = \eta \ V(X_{kjq}) + \varepsilon_{jq}$$

$V(X_{kjq})$  Systematic part measurable for the observer

$\varepsilon_{jq}$  Non systematic part, which is random for the (outside) observer

$\eta$  Scale parameter of the distribution of $\varepsilon_{jq}$

$\eta = 1$ for identification
We assume:

\[ U_{jq} \geq U_{iq}, \forall i \]

\[ V_{jq} - V_{iq} \geq \varepsilon_{iq} - \varepsilon_{jq}, \forall i \]

from which follows:

\[ P_{jq} = \text{Prob}\{ \varepsilon_{iq} \leq \varepsilon_{jq} + (V_{jq} - V_{iq}) \}, \forall i \]

\[ P_{jq} = \int f(\varepsilon) d\varepsilon \]
We assume

\[ V(X_{kjq}) = a_j + \beta_{j,q,t} x_{j,q,t} + \beta_{q,t} c_{q,t} x_{j,q,t} + \beta_q p_q x_{j,q,t} \]

or

\[ V(X_{kjq}) = a_j + a_{q,t} c_{q,t} + a_q p_q \beta_{j,q,t} x_{j,q,t} + \beta_{q,t} c_{q,t} x_{j,q,t} + \beta_q p_q x_{j,q,t} \]
Generalised Extreme Value - models

Generator of the Logit – family of models (McFadden, 1978):

$G[y_1, y_2, \ldots y_n]$ has for $y_n \geq 0$ the following properties:

- $G$ is non-negative
- $G$ is homogenous to the degree $\phi$; i.e.
  \[ G[\alpha y_1, \alpha y_2, \ldots \alpha y_n] = \alpha^\phi G[y_1, y_2, \ldots y_n] \]
- $\lim_{(y_i \to \infty)} G[y_1, y_2, \ldots y_n] = 0$; for all $i$
- The $l^{th}$ derivative of $G$ with respect to an arbitrary combination of $l$ $y_i$’s is non-negative, if $l$ is even and non-positive, if $l$ is odd.
Generalised Extreme Value - Model

The following stochastic model is then consistent with the principle of utility maximisation

$$P_q(j) = \frac{e(V_{jq}) G_i[e(V_{1q}), e(V_{2q}), ..., e(V_{nq})]}{\phi G[e(V_{1q}), e(V_{2q}), ..., e(V_{nq})]}$$

$G_i[y_1, y_2, ... y_n]$ is the first derivative of $G$ with respect to $y_i$.
Assumptions needed and degrees of freedom

The following a-priori assumptions are needed

- Specification of $V_{jq}$
- Distribution of $\varepsilon_{jq}$
- Form of $G[]$

Degrees of freedom:

- Variance-covariance-matrix of $\varepsilon_{jq}$, respectively the patterns of similarity
- Distribution of $\beta_{kjq}$
- Functional form of the $x_{kjq}$
Logit assumption $\varepsilon_{jq}$: cumulative Gumbel-distribution

\[ f(\varepsilon_{jq}) = e^{-\varepsilon_{jq}} e^{-e^{\varepsilon_{jq}}} \]

\[ F(\varepsilon_{jq}) = e^{-e^{\varepsilon_{jq}}} \]
Parameter of the Gumbel-distribution

Fixing

Mode \quad = \mu
Scale \quad = \eta

one obtains

\[ e_{jq} = \mu (\varepsilon_{jq} - \eta) \]

Mean \quad = \eta + 0.577/\eta
Variance \quad = \pi^2/ 6\eta^2
Structure of the variance-covariance-matrix $\Omega$

How similar are the $\varepsilon_{jq}$?

$$\Omega_{ij} = \sigma^2 = \begin{bmatrix} 1 & 0 & \ldots & 0 \\ 0 & 1 & \ldots & 0 \\ \vdots \\ 0 & 0 & \ldots & 1 \end{bmatrix}$$

$$\Omega_{ij} = \begin{bmatrix} \sigma^2_{11} & -\sigma^2_{21} & \ldots & -\sigma^2_{n1} \\ \sigma^2_{21} & \sigma^2_{22} & \ldots & -\sigma^2_{n2} \\ \vdots \\ \sigma^2_{n1} & \sigma^2_{n2} & \ldots & \sigma^2_{nn} \end{bmatrix}$$

Constant and independent \hspace{1cm} or \hspace{1cm} not
Example: Multinomial Logit (MNL) - model

- $G = \sum_{(\forall j)} y_j^\mu$ and $\mu = 1$

- $\varepsilon_{jq}$ are Gumbel-distributed with $\Omega_{ij} = \sigma^2$

- $\beta_{kjq}$ are constant across persons $q$ and alternatives $j$

- $V()$ is the result of the specification search
Example: binary MNL - model

\[
P_{jq} = \frac{e^{V_{jq}}}{\sum_{n} e^{V_{nq}}} \quad \forall n
\]

Binärer Fall: \( V(iq) = 0 \)
MNL: *Irrelevance of independent alternatives*

IIA: the ratio of the choice probabilities of any two alternatives is independent of the total number of alternatives

\[
\frac{P_i}{P_j} = \frac{\sum_{\forall n} e^{V_i}}{\sum_{\forall n} e^{V_n} e^{V_j}}
\]

\[
= e^{V_i - V_j}
\]

\[
= Const
\]
Capturing similarity through structure of $\Omega$

A-priori assumptions about the structure of $\Omega$

- Nested Logit (NL) (Alternative -> Nest)
- Cross-Nested-Logit (CNL) (Alternative -> Nests)
- Ordered Logit (OL) (Alternative -> Nested according to some natural ranking/order)
- Generalised Nested Logit (GNL)
- Network GEV - Model (NGEV)
Error components approach

We can add

\[ U_{jq} = U(X_{kjq}) = \eta V(X_{kjq}) + \phi_{jq} + \epsilon_{jq} \]

With

\[ \phi_{jq} \sim \text{Normal distributed (using some factor structure)} \]

\[ \epsilon_{jq} \sim \text{Gumbel distributed as before} \]
Assumptions about $\beta_{kjq}$

Is

\[ \beta_{kjq} = \beta_{kj*} = \text{constant across all persons q?} \]
\[ \beta_{kjq} = \beta_{k**} = \text{constant across persons q and alternatives j?} \]

or

\[ \beta_{kjq} \sim \text{a-priori set distribution with a mean } \beta_{kj*} \text{ and} \]
\[ \text{Variance } \sigma^2_{\beta_{kj*}} \text{ over persons q alternative j and variable k} \]

or is

\[ \beta_{kj*} = f(\sum X_{kjq}), \text{ a function of other variables} \]
Mixed and error component logit

Assuming distributed parameters results in

• Mixed MNL (MMNL) or random parameter logit (RPL)

• Error components logit (ECL)

Other GEV models can be substituted for the MNL
Estimation

Maximum likelihood approaches:

- GEV family using analytical approaches
- MMNL and ECL using simulated maximum likelihood approaches

Implemented in SAS, (SPSS), LIMDEP, ALOGIT, BIOGEME, or various Gauss-codes
Swiss Value of Travel Time Savings (VTTS) study

Steering group organised by SVI (chair: U. Weidmann, SBB)

Core team:
- G Abay
- KW Axhausen
- A König

External advisers:
- JJ Bates
- M Bierlaire
Survey approach

Add-on to ongoing RP – survey (KEP of SBB)

Pretests:
- Route choice
- Mode choice
- Destination choice

Main study
- Route choice
- Mode choice
## Route choice car (Main study)

<table>
<thead>
<tr>
<th>Route A</th>
<th>Route B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reisekosten: 18 Fr.</td>
<td>Reisekosten: 23 Fr.</td>
</tr>
<tr>
<td>Gesamtfahrzeit: 40 Min.</td>
<td>Gesamtfahrzeit: 20 Min.</td>
</tr>
<tr>
<td>davon in stop and go: 10 Min.</td>
<td>davon in stop and go: 5 Min.</td>
</tr>
<tr>
<td>davon freie Fahrt: 30 Min.</td>
<td>davon in freier Fahrt: 15 Min.</td>
</tr>
</tbody>
</table>

← Ihre Wahl →
Mode choice (Main study)

<table>
<thead>
<tr>
<th></th>
<th>PW</th>
<th>Bahn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reisekosten</td>
<td>13 Fr.</td>
<td>23 Fr.</td>
</tr>
<tr>
<td>Gesamtfahrzeit</td>
<td>30 Min.</td>
<td>20 Min.</td>
</tr>
<tr>
<td>davon in stop and go</td>
<td>5 Min.</td>
<td>Takt: 30 Min.</td>
</tr>
<tr>
<td>davon freie Fahrt</td>
<td>25 Min.</td>
<td>Anzahl Umsteigen: 0-mal</td>
</tr>
</tbody>
</table>

[←← ←←] Ihre Wahl [→→ →→]
### Response behaviour (Main study)

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviewed for KEP</td>
<td>5560</td>
<td>(during weeks 22 to 40 of 2002)</td>
</tr>
<tr>
<td>Willing to participate</td>
<td>3216</td>
<td>(58% of interviewees)</td>
</tr>
<tr>
<td>Experiments sent out</td>
<td>2317</td>
<td>(72% of willing interviewees)</td>
</tr>
<tr>
<td>Returns</td>
<td>1222</td>
<td>(53% of experiments sent out)</td>
</tr>
<tr>
<td>Chosen mode</td>
<td>Car availability</td>
<td>RC chosen mode</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Car</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Car</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Bus</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Rail</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Bus</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Rail</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Variable</td>
<td>MZ 2000</td>
<td>KEP</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>Females</td>
<td>51</td>
<td>54</td>
</tr>
<tr>
<td>Below 35</td>
<td>40</td>
<td>26</td>
</tr>
<tr>
<td>36-55</td>
<td>32</td>
<td>40</td>
</tr>
<tr>
<td>Above 55</td>
<td>28</td>
<td>34</td>
</tr>
<tr>
<td>Regular schooling</td>
<td>32</td>
<td>22</td>
</tr>
<tr>
<td>Professional training</td>
<td>41</td>
<td>53</td>
</tr>
<tr>
<td>Tertiary education</td>
<td>27</td>
<td>27</td>
</tr>
</tbody>
</table>
Sample drift: Shares by mobility tools and income [%]

<table>
<thead>
<tr>
<th>Variable</th>
<th>MZ 2000</th>
<th>KEP</th>
<th>Willing to participate</th>
<th>Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount card</td>
<td>35</td>
<td>38</td>
<td>43</td>
<td>54</td>
</tr>
<tr>
<td>National season</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Car available</td>
<td>77</td>
<td>63</td>
<td>62</td>
<td>73</td>
</tr>
<tr>
<td>Up to 40 kSFr</td>
<td>21</td>
<td>-</td>
<td>-</td>
<td>19</td>
</tr>
<tr>
<td>40 – 80 kSFr</td>
<td>42</td>
<td>-</td>
<td>-</td>
<td>35</td>
</tr>
<tr>
<td>80 – 125 kSFr</td>
<td>27</td>
<td>-</td>
<td>-</td>
<td>33</td>
</tr>
<tr>
<td>125 and more kSFr</td>
<td>11</td>
<td>-</td>
<td>-</td>
<td>14</td>
</tr>
</tbody>
</table>
Modelling strategy

Experimental variables only

+ Inertia indicators
+ Socio-demographic variables
+ Distance and income elasticities
+ RPL for cost and travel times
+ Interaction with trip purpose

For each experiment and then for pooled estimates
Specification of the elasticities

Non-linear elements of the utility function can be specified in Biogeme:

\[ \beta_{Cost} \left( \frac{\text{Income}}{\text{Mean income}} \right)^{\varepsilon_{Income}} \left( \frac{\text{Trip length}}{\text{Mean trip length}} \right)^{\varepsilon_{Trip length}} \times \text{Cost} \]

(Adopted from recent reanalysis of UK VTTS study)
Biogeme

General GEV-modell estimation tool:

- MNL, NL, CNL, NetworkGEV
- Mixed logit
- Non-linear elements in the utility function, including Box-Cox transforms
- Direct estimation of error scales

See for the freeware:

http://roso.epfl.ch/biogeme
Trade-offs offered (Route choice rail)

![Graph showing trade-offs offered in CHF/h and share of situations in percentage](image)

- Share of situations [%]
- Trade-off offered [CHF/h]

Legend:
- 0-5
- 10-15
- 20-25
- 30-35
- 40-45
- 50-55
- 60-65
- 70-75
- 80-85
- 90-95
Model trajectory: Mode choice – public transport user

Value of travel time savings [CHF/h]

Adjusted Rho2

Expansion of the utility function

SP variables + Inertia + RPL + Elasticities + by purpose

All purposes Commuters Shopping Business Leisure Rho2
Value of travel time savings: Car commuters

![Graph showing the relationship between income, distance, and value of travel time savings.](image-url)

- **Value of travel time savings** in [CHF/h]
- **Income** in [CHF/Jahr]
- **Distance** in [km]
Fusing information

Problem: Multiple different views of the same parameters via different samples

Fusion while account for error scale differences, for example

\[ U_{jq1} = U(X_{kjq1}) = \eta_1 \ V(X_{kjq1}) + \epsilon_{jq1} \]
\[ U_{jq2} = U(X_{kjq2}) = \eta_2 \ V(X_{kjq2}) + \epsilon_{jq2} \]

with \( \eta_1 = 1 \)

and one or more \( \beta_{kjq1} = \beta_{kjq2} \)
## Relative scaling of the error distributions

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Route choice only</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Parameter</td>
<td>T-test</td>
</tr>
<tr>
<td>Mode choice</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Route choice car</td>
<td>1.82</td>
<td>3.10</td>
</tr>
<tr>
<td>Route choice rail (car users)</td>
<td>0.97</td>
<td>1.19</td>
</tr>
<tr>
<td>Route choice rail (rail user)</td>
<td>1.00</td>
<td>-</td>
</tr>
</tbody>
</table>
Values of travel time savings at population mean

<table>
<thead>
<tr>
<th></th>
<th>Commuter</th>
<th>Shopping</th>
<th>Business</th>
<th>Leisure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>21.4</td>
<td>18.1</td>
<td>32.5</td>
<td>12.3</td>
</tr>
<tr>
<td></td>
<td>2.9</td>
<td>3.8</td>
<td>-</td>
<td>0.8</td>
</tr>
<tr>
<td>Rail</td>
<td>17.7</td>
<td>13.8</td>
<td>30.3</td>
<td>9.7</td>
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<tr>
<td></td>
<td>1.7</td>
<td>2.1</td>
<td>-</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Values and variances in [sFr/h];

Variances were computed by a Taylor expansion

VTTS for commuter is equivalent to 30-35% of average hourly wage
Comparison with other recent studies

- Commuter VTTS [2003 CHF/h]

- Year

- Car - European studies
- Rail - European studies
- Car - CH - VTTS
- Rail - CH - VTTS
Challenges and outlook: Data collection

RP:
- Expanding the variable set
- Maintaining response rates
- Incorporating tracing technologies

SP:
- Stability of results
- Size of experiment (number of variables, number of choice situations)
- Adaptive designs
- Hierarchical designs
Challenges and outlook: Choice modelling

- Measuring similarity in $V()$
- Identification of the structure of $\Omega$ from the observations
- Identification of the choice sets

- Non-parametric MMNL and suitable choice of parametric distributions
- Speed of estimation

- Stability of substantive results

- Integration into agent-based simulations


