Preferred citation style for this presentation

Axhausen, K.W (2006) The Swiss National Model and the Swiss value of travel time savings: Aggregate and disaggregate results, presentation at the University of Toronto, Toronto, August 2006.

The Swiss National Model and the Swiss value of travel time savings: Aggregate and disaggregate results

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August 2006

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Institute for Transport Planning and Systems

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Context: New Swiss CBA - guidelines

SN 671 800	Framework and Approach
SN 671 801	Discount rate
SN 671 802	Value of passenger travel time savings
SN 671 803	Value of freight travel time savings
SN 671 804	Value of safety improvements
SN 671 805	Prediction and valuation of system reliability
SN 671 806	Road operating costs
SN 671 807	Prediction and valuation of external effects

Swiss VTTS: Project team

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

Core team:

- G Abay
- KW Axhausen
- A König

- S. Hess

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

Destination choice (Pretest I and II)

Einkaufszentrum A	Einkaufszentrum B
Fahrzeit: 30 Minuten	Fahrzeit: 20 Minuten
Reisekosten: 7 Fr.	Reisekosten: 5 Fr.
Preis Warenkorb: 120 Fr.	Preis Warenkorb: 140 Fr.

☐ **← Ihre Wahl →** ☐

Route choice car (Pretest I)

Route A	Route B
Fahrzeit: 40 Minuten	Fahrzeit: 20 Minuten
Reisekosten: 18 Fr.	Reisekosten: 23 Fr.
Stauanteil Fahrt: 25%	Stauanteil Fahrt: 15%

☐	← **Ihre Wahl** →	☐

Route choice car (Pretest I)(Pretest II)

Route A	Route B
Reisekosten: 18 Fr.	Reisekosten: 23 Fr.
Gesamtfahrzeit: 40 Minuten	Gesamtfahrzeit: 20 Minuten
Davon in stop and go: 10 Minuten	Davon in stop and go: 5 Minuten

☐	**← Ihre Wahl →**	☐

Route choice car (Pretest I) (Main study)

Route A	Route B
Reisekosten: 18 Fr.	Reisekosten: 23 Fr.
Gesamtfahrzeit: 40 Min.	Gesamtfahrzeit: 20 Min.
davon in stop and go: 10 Min.	davon in stop and go: 5 Min.
davon freie Fahrt : 30 Min.	davon in freier Fahrt: 15 Min.

☐	**← Ihre Wahl →**	☐

Route choice rail (Main study)

Route A	Route B
Reisekosten: 20 Fr.	Reisekosten: 30 Fr.
Fahrzeit: 40 Min.	Fahrzeit: 20 Min.
Fahrplantakt : 15 Min.	Fahrplantakt : 30 Min.
Anzahl Umsteigen: 1-mal	Anzahl Umsteigen: 0-mal

☐ **← Ihre Wahl →** ☐

Mode choice (Main study)

PW	Bahn
Reisekosten: 13 Fr.	Reisekosten: 23 Fr.
Gesamtfahrzeit: 30 Min.	Gesamtfahrzeit: 20 Min.
davon in stop and go: 5 Min.	Takt: 30 Min.
davon freie Fahrt : 25 Min.	Anzahl Umsteigen: 0-mal

☐	**← Ihre Wahl →**	☐

Experiments and number of choice situations

Chosen mode	Car availability	MC car – rail	MC car – bus	RC car	RC bus	RC rail
Car	Yes	6		6		
Car	Yes	6				9
Bus	Yes		6		9	
Rail	Yes	6				9
Bus	No				9	
Rail	No					9

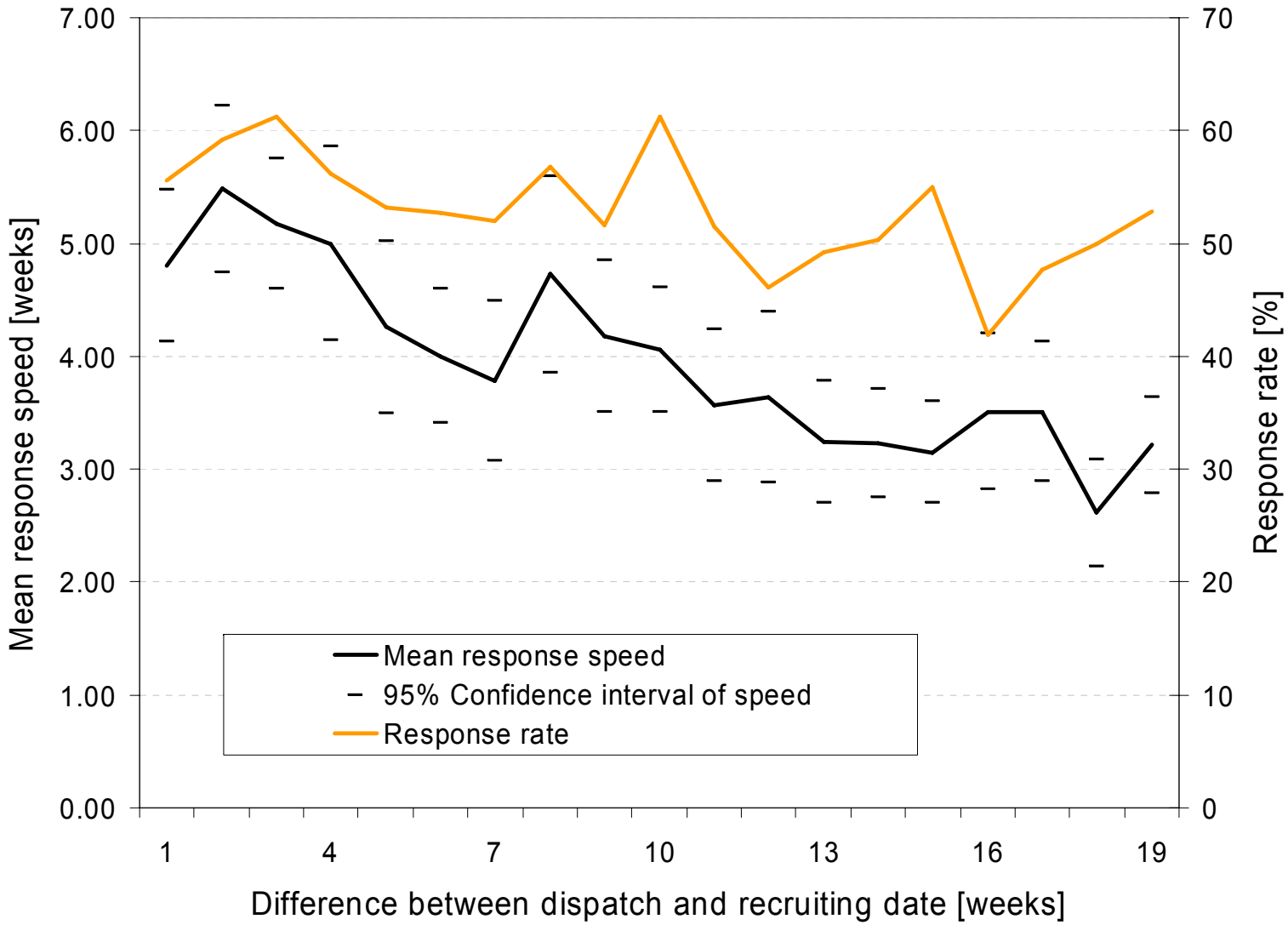
Response behaviour (Main study)

Interviewed for KEP:	5560	(during weeks 22 to 40 of 2002)
Willing to participate:	3216	(58% of interviewees)
Experments sent out:	2317	(72% of willing interviewees)
Returns:	1222	(53% of experiments sent out)

Response rate for the different experiments

Chosen mode	Car availability	RC chosen mode	Number of choice situations	Response rate
Car	Yes	Yes	15	52.2
Car	Yes	No	15	48.6
Bus	Yes	Yes	15	54.4
Rail	Yes	Yes	15	65.7
Bus	No	Yes	9	37.7
Rail	No	Yes	9	50.2

Response rate and response speed



Sample drift: Shares by age, gender and education [%]

Variable	MZ 2000	KEP	Willing to participate	Returns
Females	51	54	50	41
Below 35	40	26	28	26
36-55	32	40	41	49
Above 55	28	34	31	26
Regular schooling	32	22	16	10
Professional training	41	53	54	46
Tertiary education	27	27	30	44

Sample drift: Shares by mobility tools and income [%]

Variable	MZ 2000	KEP	Willing to participate	Returns
Discount card	35	38	43	54
National season	6	6	7	11
Car available	77	63	62	73
Up to 40 kSFr	21	-	-	19
40 – 80 kSFr	42	-	-	35
80 – 125 kSFr	27	-	-	33
125 and more kSFr	11	-	-	14

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:

$$\beta_{Cost} * \left(\frac{Income}{Mean\ income} \right)^{\varepsilon_{Income}} * \left(\frac{Trip\ length}{Mean\ trip\ length} \right)^{\varepsilon_{Trip\ length}} * Cost$$

Biogeme

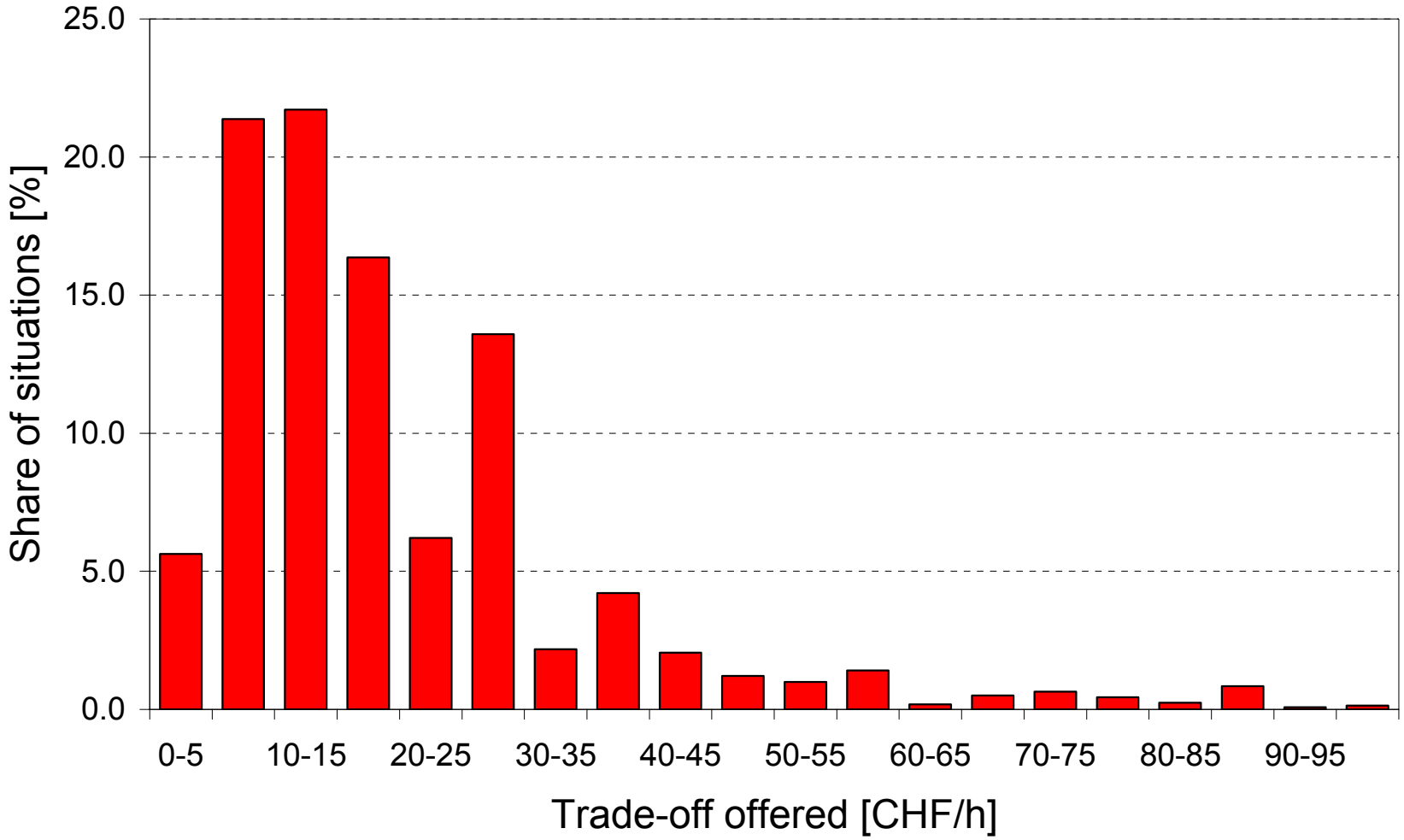
General GEV-modell estimation tool:

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

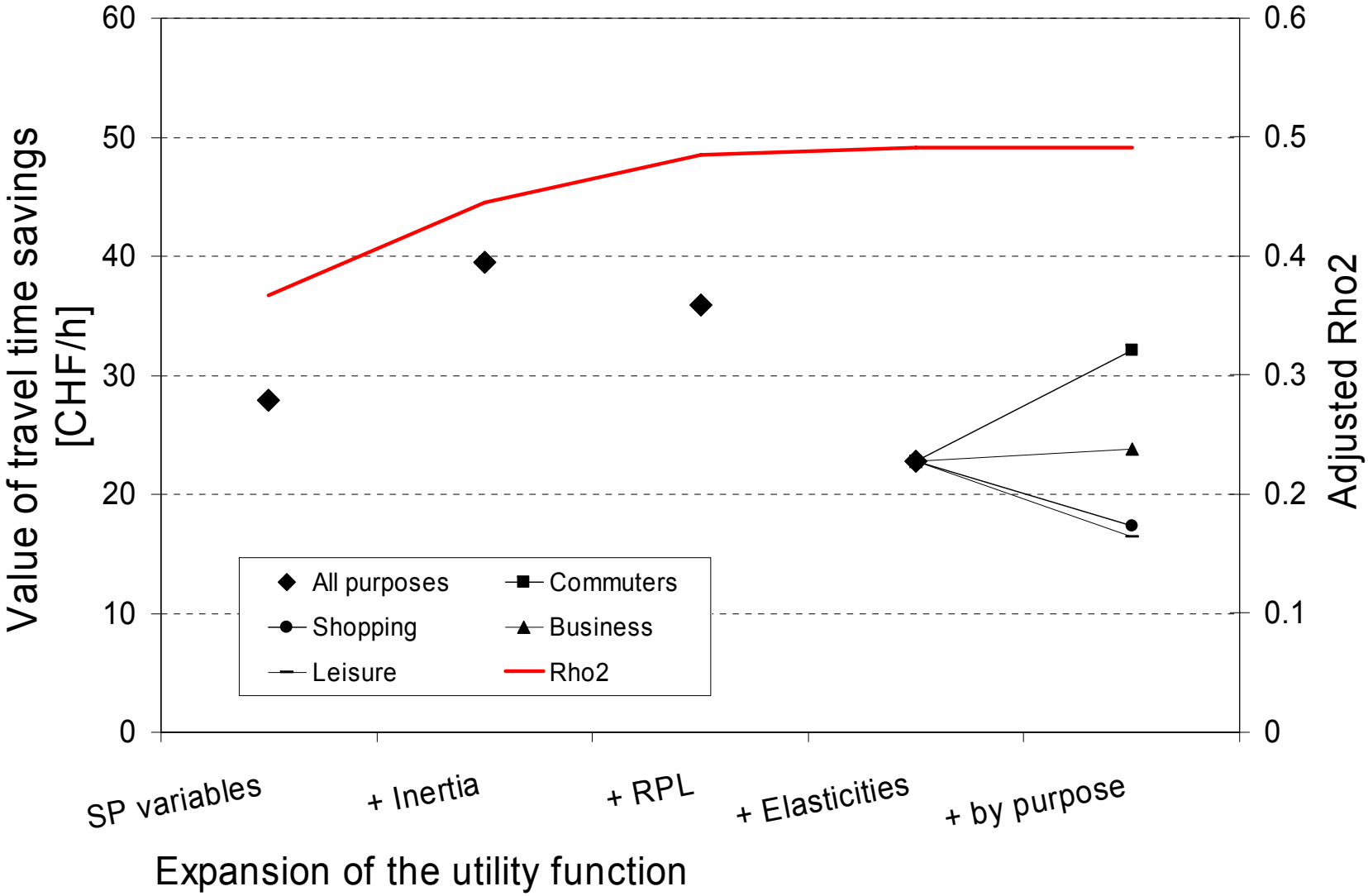
See for the freeware:

http://roso.epfl.ch/biogeme

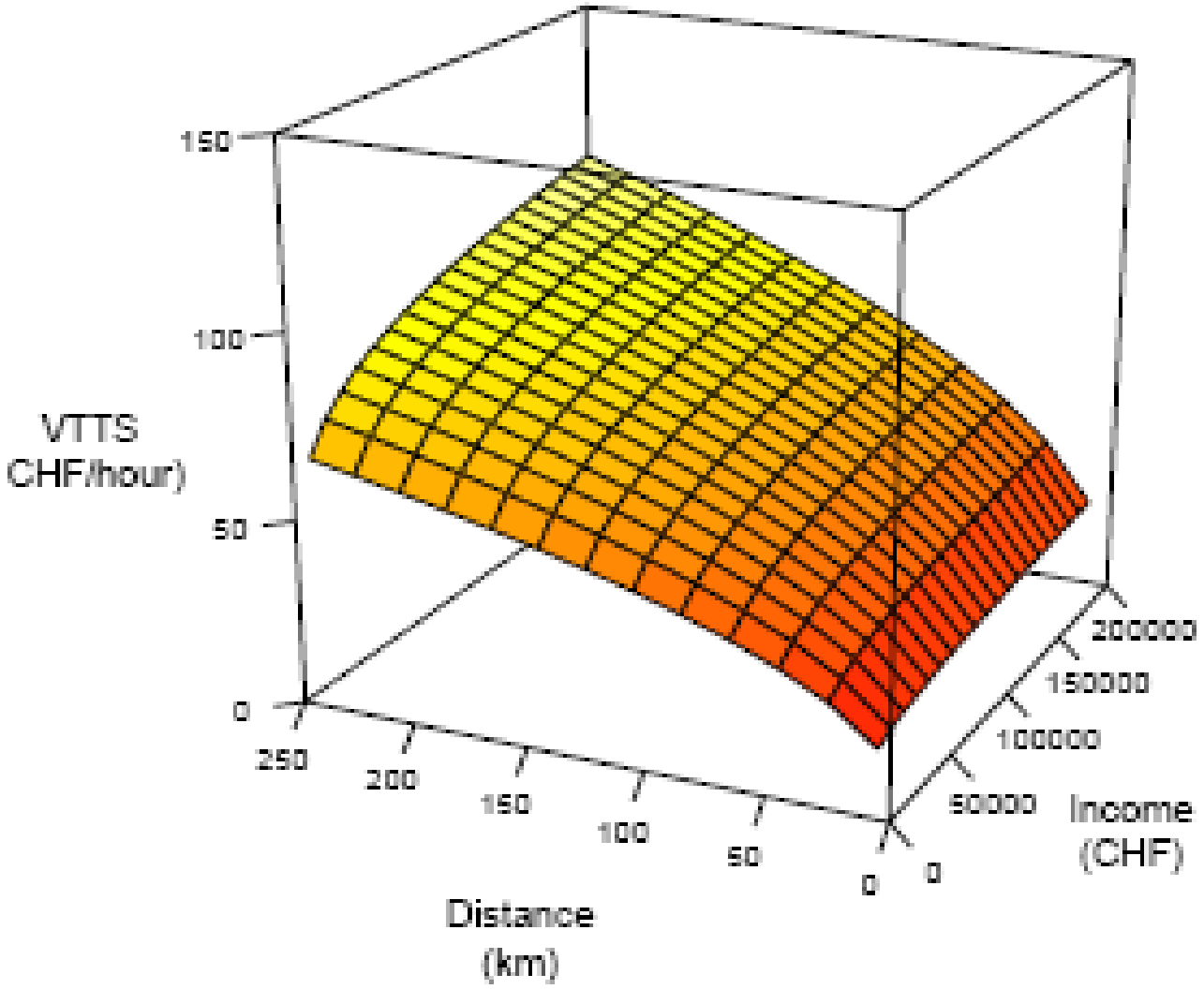
Trade-offs offered (Route choice rail)



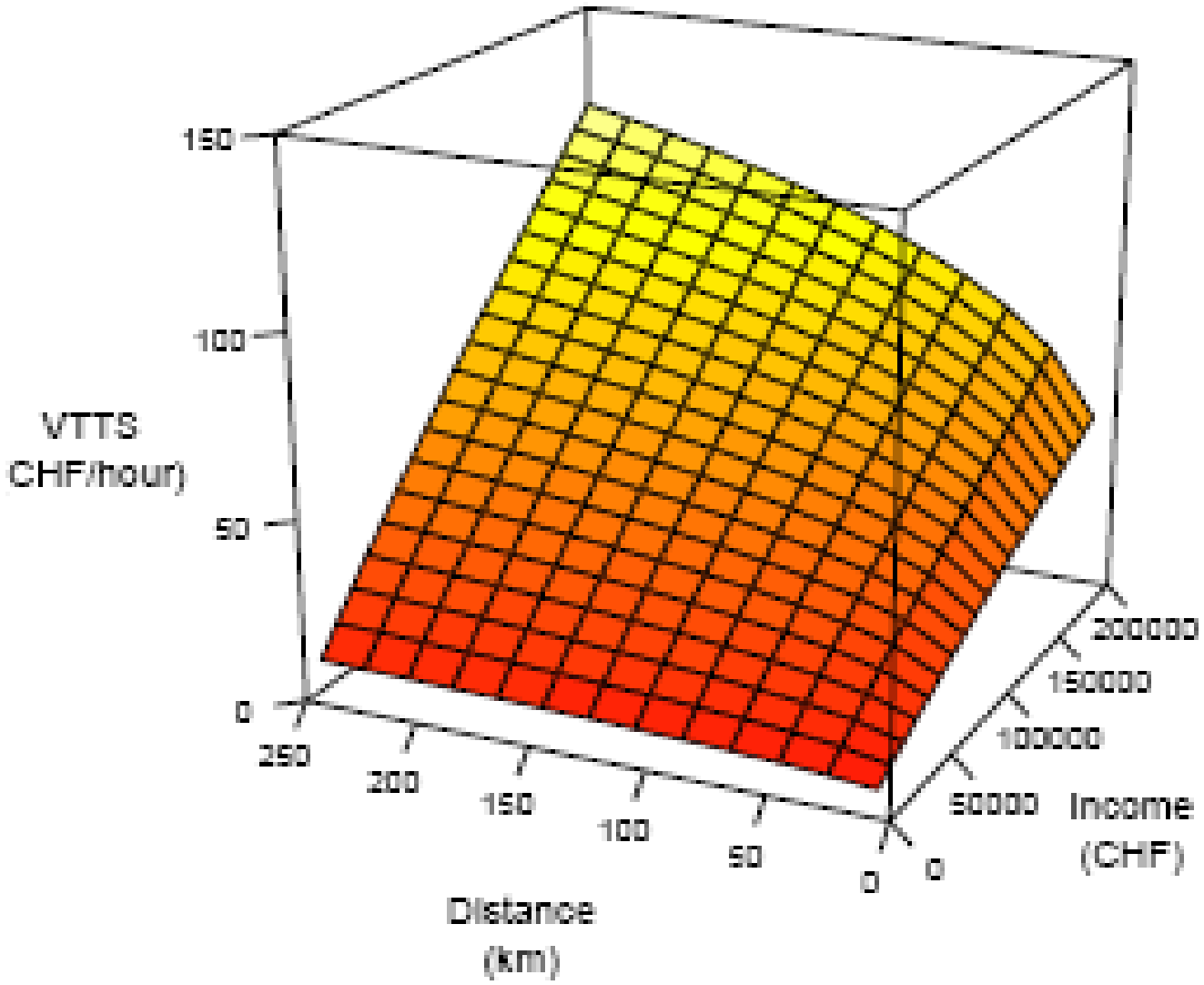
Model trajectory: MC – public transport user



Value of travel time savings: Car commuters



Value of travel time savings: Rail business travellers



Relative scaling of the error components

Experiment	Route choice only		Combined	
	Para-meter	T-test	Para-meter	T-test
Mode choice	-	-	0.66	8.57
Route choice car	1.82	3.10	1.39	2.47
Route choice rail (car users)	0.97	1.19	1.05	0.83
Route choice rail (rail user)	1.00	-	1.00	-

Value of travel time savings: Sample means

	Commuter	Shopping	Business	Leisure
Car	19.0 ±0.7	17.8 ±1.2	27.7 ±3.3	18.8 ±1.5
Rail	18.9 ±0.6	13.1 ±0.7	25.2 ±1.3	11.9 ±0.4

Values and st. dev [sFr/h]

National model: project team and client

Team:

- M. Vrtic, P Fröhlich, N Schüssler, KW Axhausen, IVT, ETH Zürich
- D Lohse, C Schiller, H Teichert, Lehrstuhl für Theoretische Verkehrsplanung, TU Dresden
- S. Dasen, B. Singer, Emch+Berger, Zürich

Client:

- ARE
- ASTRA
- BAV

Scope and details

Scope:

- Trip generation (doubly constraint) by purpose
- Destination choice
- Mode choice (road, rail/bus, slow modes)
- Route choice

Spatial resolution:

- about 3’150 municipalities and urban “Kreise” inside the country
- About 150 zones outside Switzerland

Networks:

- IVT road network (motorways, major roads, some others)
- Full national railway timetable
- Selected bus lines

Approach

Generation, distribution and mode choice (EVA by Lohse):

- Doubly constraint approach based on
  - Activity-pair specific trip rates
  - Nested logit model of destination and route choice

Route choice (as implemented in VISUM 8.21)

- UE assignment for the road matrices
- SUE time table based assignment for public transport

EVA: Trip generation

Key ideas:

- Activity – purpose pairs (defining trips)
- Market segments are associated with the pairs and have relevant generation rates
- (Multiple) opportunity types are associated with the pair
- The constraints can either be soft or hard

EVA: Trip generation

From	To					
	Home H	Work W	Education E	Business B	Shopping S	Leisure L
Home	-	HW	HE	HB	HS	HO
Work	WH	WO				
Education	EH	OW	BO, SO, OB, OS, OO			
Business	BH					
Shopping	SH					
Leisure	OH					

EVA: Distribution and mode choice

$$BW_{ijk} = P\left(W \middle| \left(A_i \cap E_j \cap M_k\right)\right)$$

A(i): zone i has been chosen as origin

E(j) zone j has been chosen as destination

M(k) mode k has been chosen

W trip from i to j using k is accepted with regard to the generalized costs

EVA: Distribution and mode choice

v(ijk): trips from zone i to zone j with mode k

V: Total number of trips

$$v_{ijk} = \frac{P\left(\left(A_i \cap E_j \cap M_k\right)\middle|W\right)}{\sum_{i'}\sum_{j'}\sum_{k'} P\left(\left(A_{i'} \cap E_{j'} \cap M_{k'}\right)\middle|W\right)} \cdot V = \cdot$$

$$= \frac{P\left(A_i\right) \cdot P\left(E_j\right) \cdot P\left(M_k\right) \cdot P\left(W\middle|\left(A_i \cap E_j \cap M_k\right)\right)}{\sum_{i'}\sum_{j'}\sum_{k'} P\left(A_{i'}\right) \cdot P\left(E_{j'}\right) \cdot P\left(M_{k'}\right) \cdot P\left(W\middle|\left(A_{i'} \cap E_{j'} \cap M_{k'}\right)\right)} \cdot V$$

EVA: Trip generation and mode choice: Constraints

$$v_{ijk} = BW_{ijk} \cdot \frac{Q_i}{V} \cdot q_i \cdot \frac{Zmax_j}{\sum_{j'} Zmax_{j'}} \cdot z_j \cdot \frac{M_k}{V} \cdot a_k \cdot f$$

$$\left.\begin{aligned} Q_i &= \sum_j \sum_k v_{ijk} \\ Zmax_j \geq Z_j &= \sum_i \sum_k v_{ijk} \\ M_k &= \sum_i \sum_j v_{ijk} \end{aligned}\right\} \text{ Constraints}$$

EVA: Solution algorithm

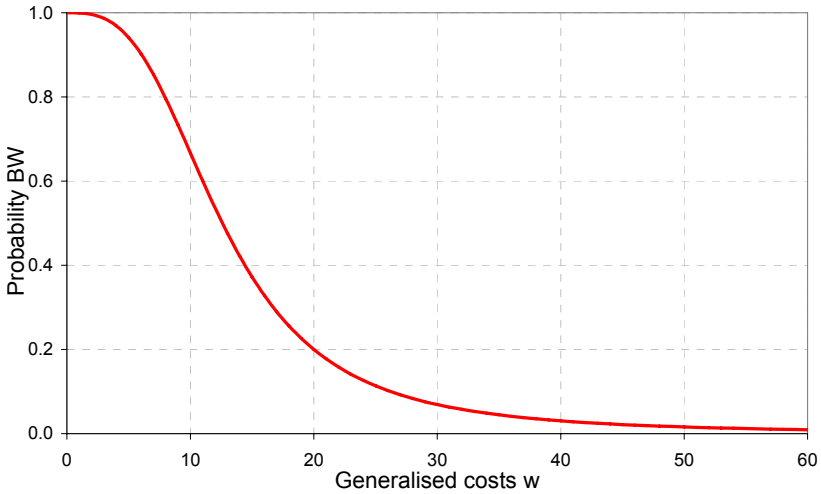
Lohse et al. show that:

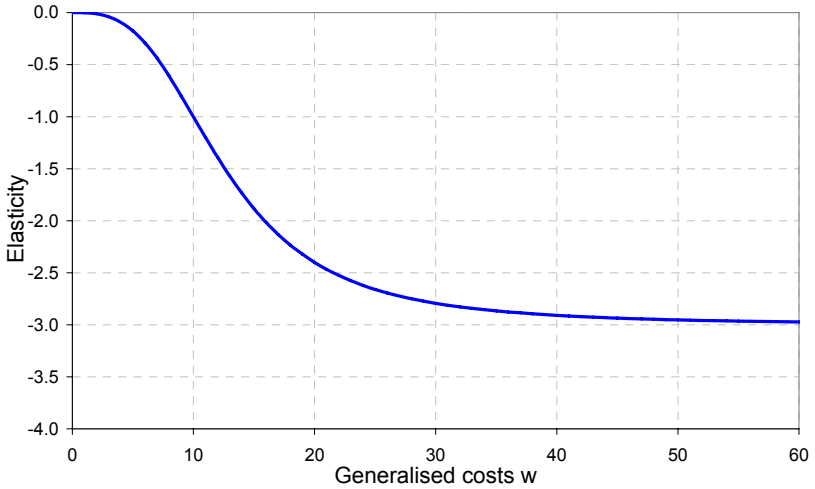
- Model can be derived as a solution to an information minimisation problem
- A fast iterative procedure is available to calculate the balancing factors

Functional form for BW

Lohse prefers:

$$BW = f(w) = \left[1 + \left(\frac{w}{F}\right)^{G}\right]^{-\frac{E}{G}} \qquad \varepsilon(w) = -E \cdot \frac{w^{G}}{F^{G} + w^{G}}$$





Destination and mode choice NL model

Approach for 10 activity – purpose pairs:

- Mode/route choice parameters from previous SP study
- Destination choice parameters newly estimated
- Adjustment of cost/time parameters with BC-transform to match trip length distribution

Destination choice parameters:

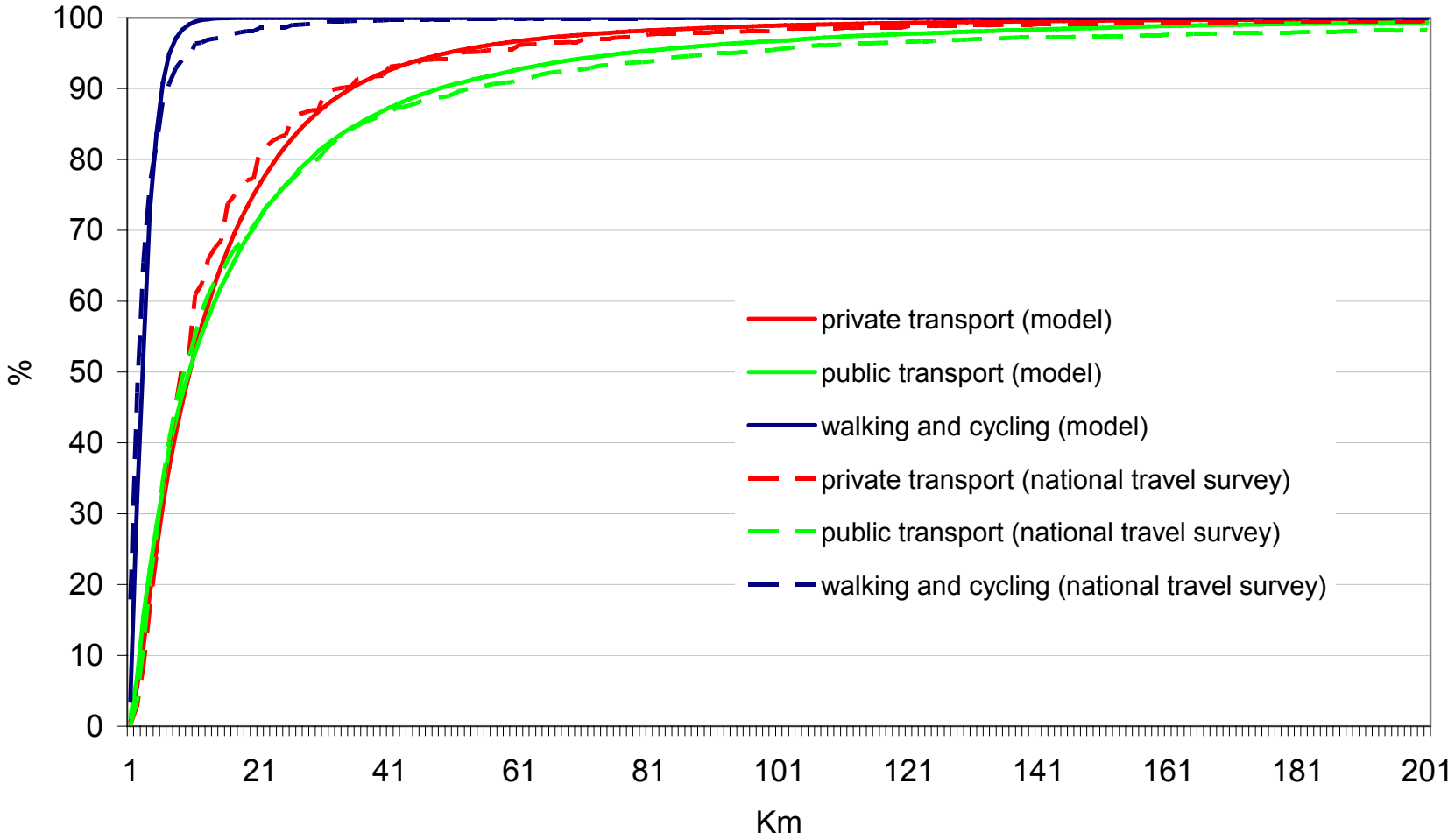
Variable	HW	WH	HE	EH	HB	BH	HS	SW	WL	LW
Jobs	0.266				0.339					
Wage earners		0.322				0.413				
Education facilities			0.094							
Residents				0.296				0.384		0.156
Sales area							0.175			
Shopping centre							0.023			
Leisure facilities									0.166	
N-observations	23000	23000	7700	7700	6900	6900	19800	19800	42800	42800
ρ^2	0.03	0.03	0.34	0.34	0.14	0.14	0.22	0.22	0.19	0.17

Attraction variables are all logarithmic values

Adjusted time and cost parameters

Parameter	HW, WH	HE, EH	HB, BH	HS, SW	WL, LW
λ-Travel time car	0.97	0.70	0.05	0.72	0.01
λ-Costs car	0.97	0.60	0.01	0.72	0.01
λ-Travel time PT	0.95	0.70	0.05	0.65	0.01
λ-Costs PT	0.95	0.70	0.01	0.65	0.01

Trip length distribution

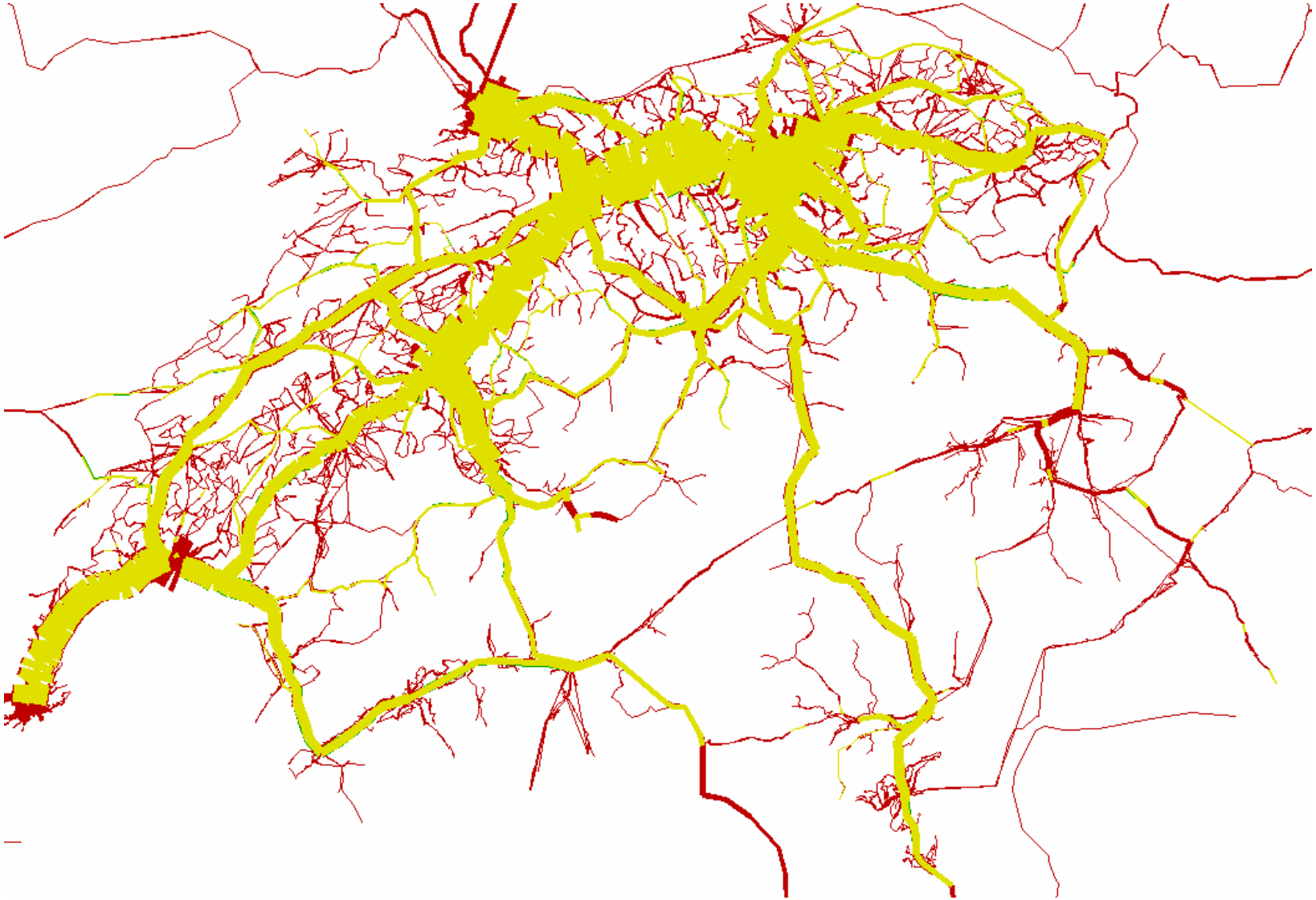


Interzonal trip generation and mode choice by purpose

Mode and data set	Work	Edu-cation	Business	Shop	Leisure	Sum
Car						
Model	3.786	0.095	0.949	1.677	4.142	10.633
NTS 2000	3.851	0.253	0.911	1.622	3.885	10.522
Census 2000	3.334	0.082	--	--	--	--
Public transport						
Model	1.367	0.562	0.086	0.346	0.853	3.214
NTS 2000	1.031	0.538	0.096	0.409	0.891	2.965
Census 2000	1.213	0.504	--	--	--	--
Walking and cycling						
Model	0.190	0.144	0.056	0.371	1.046	1.808
NTS 2000	0.472	0.383	0.060	0.408	1.203	2.528
Census 2000	0.186	0.157	--	--	--	--

Comparison after calibration: Road transport

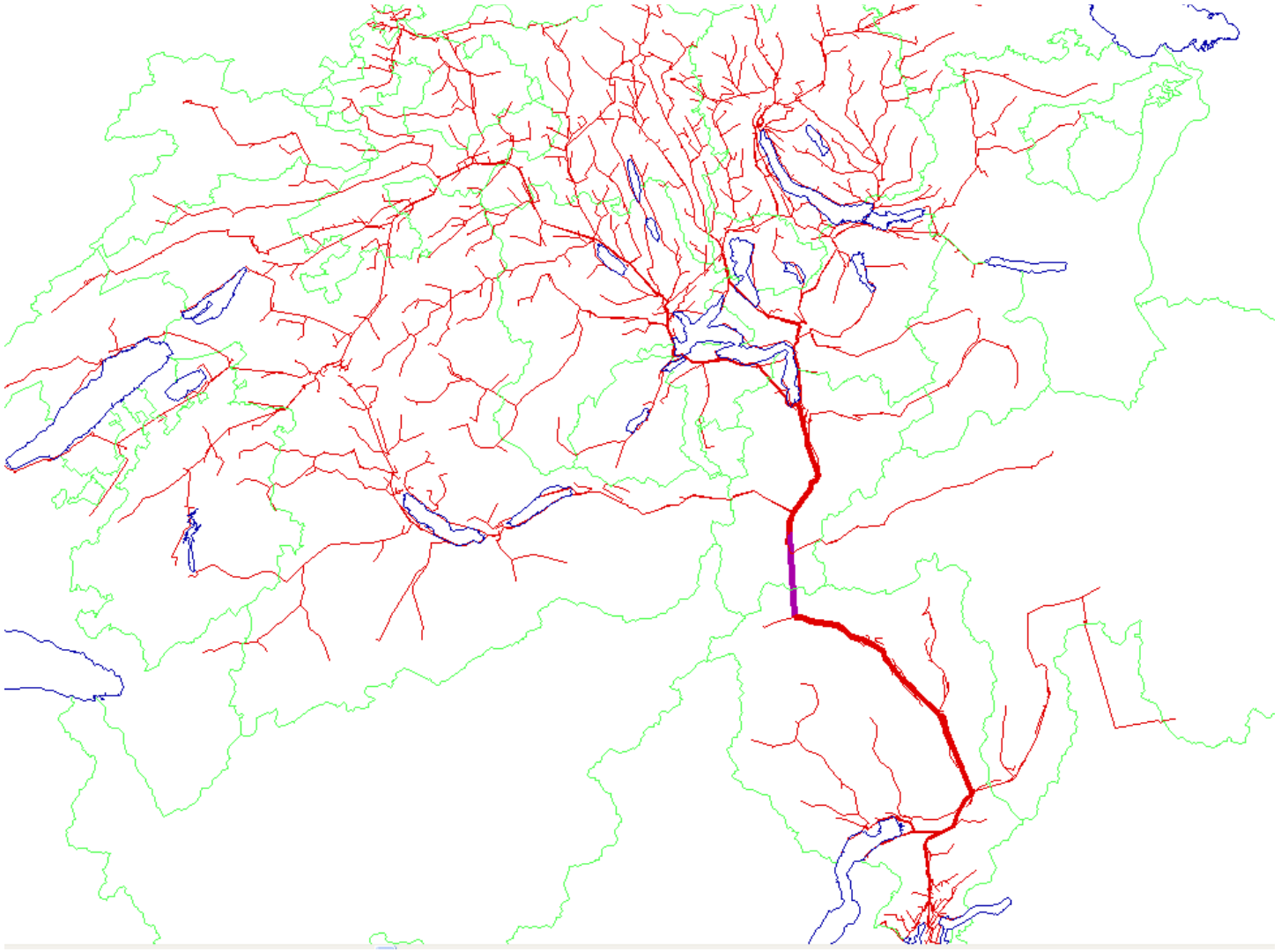
Comparison after calibration: Public transport



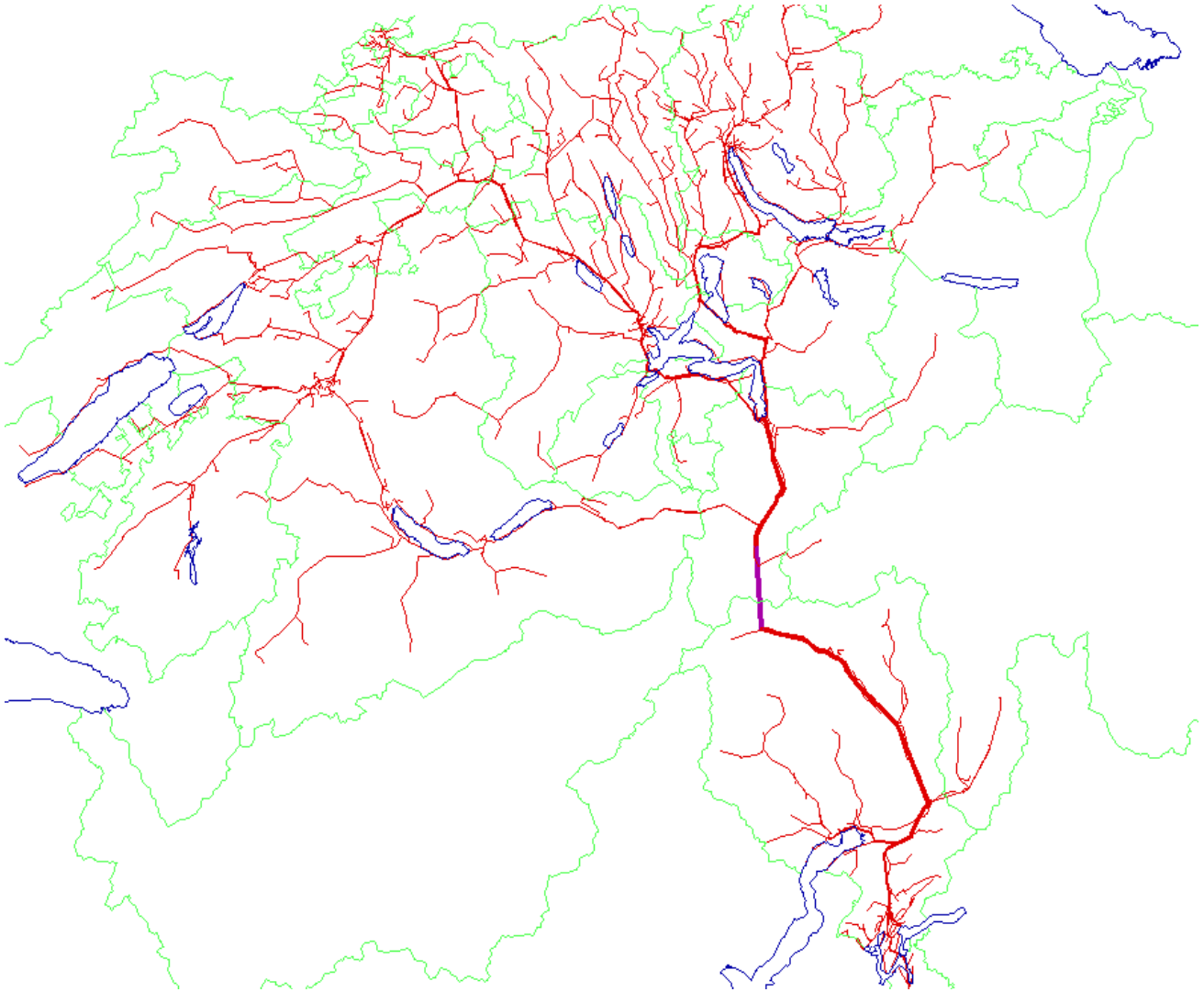
Fit with counts

	Motorised private transport	Public transport
Number of cross-section counts	602	1210
Mean weigthed deviation of absolute values in %	5.97	7.68
Coefficient of correlation	0.9938	0.9968
Root of mean square error	841.98	683.53

Model predicted flows through the Gotthard tunnel



Counted flows through the Gotthard tunnel



Summary and challenges

Methodological:

- Consistency in estimation and application of choice models ?
- Consistency of route and mode choice
- Dividing the model as generation / destination & connection choice ?
- Soft and hard destination constraints
- Including pricing ?

Substantial:

- Large scale model established within 18 months
- Consistent generation, destination and mode choice approach

References

Axhausen, K.W., S. Hess, A. König, G. Abay, J.J. Bates and M. Bierlaire (2006) State of the art estimates of the Swiss value of travel time savings, *Arbeitsberichte Verkehrs- und Raumplanung*, **372**, IVT, ETH Zürich, Zürich.

Vrtic, M., D. Lohse, P. Fröhlich, C. Schiller, N. Schüssler, H. Teichert and K.W. Axhausen (2005) A simultaneous two-dimensionally constraint disaggregate trip generation, distribution and mode choice model: Theory and application for the Swiss national model, Paper presented at the ERSA conference, Amsterdam, July 2005

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