Axhausen, K.W. (2012) GPS, GSM, Diary: How to capture travel behaviour?, presentation at Northwestern University, Evanston, July 2012.

GPS, GSM, Diary: How to capture travel behaviour?

KW Axhausen

IVT ETH Zürich

July 2012





Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich Stated choice and diaries:

- Claude Weis
- Alexander Erath

Social networks:

- Timo Ohnmacht
- Andreas Frei
- Matthias Kowald

GPS surveys and analysis:

- Nadine Rieser Schüssler
- Lara Montini



Evidence

Productivity growth in Western Europe



Adapted from Galor and Weil (2000)

Road based – Switzerland 1950 and 2000



Scherer, 2004

VTTS all purposes Switzerland 2001 - 2006



Real prices of telekommunication



Quelle: nach FCC (2001)

At home



Breakfast







Tour 1



Elements of the generalised costs of the movement:

- Duration of the stages
- Routes of the stages
- Circumstances of the stages (congested; parking search)
- Monetary (decision relevant) costs of the stages
- Joint activities during the stages
- Joint travel with whom
- Time pressure of the stages

Elements of the generalised costs of the **non-chosen** alternatives (modes * routes/connections):

- Duration of the stages
- Routes of the stages
- Circumstances of the stages (congested; parking search)
- Monetary (decision relevant) costs of the stages

Elements of the generalised costs of the activity:

- Congestion
- Price levels
- Price worthiness (value for money)
- Social mileu
- Purpose of the activity
- Joint activities during the activity
- Joint activity with whom and expenditure sharing, if any
- Planning horizon of the activity

Elements of the generalised costs of the **non-chosen** alternatives (locations * purposes):

- Congestion
- Price levels
- Price worthiness (value for money)
- Social mileu



Dimension	Diary	GSM	GPS
Trips	Easy	Impossible	Post-processing
Completeness	Respondent dependent	No	Yes, but data Ioss possible
Duration	Rounded to the next 5, 15 min	No	Exactly
Destinations	(Exactly)	Cell tower	Exactly
Purpose	Yes	No	Imputation
Company	Partially	No	No
Routes	Expensively	(Impossible)	Exactly
Recruitment	F(response burden)	(Easy)	F(response burden)
Response period	1 (-42) days	(Unlimited)	(1-) 7-14 (-) days

Response rate = f(response burden) @ IVT



Diaries

- Geocoded CATI interview (LINK)
 - Person- and household socio-demographics
 - Stage-based travel diary
 - Routes of car/motorcycle-stageswere identified with two waypoints (interviewer had map interface)
- Add-on modules for sub-samples (LINK)
 - One-day excurions
 - Long-distance travel
 - Attidues to transport policy
- Integrated, but independent SC questionnaire (IVT)
 - SC mode choice
 - SC route and deperture time choice

Innovation in destination choice



- Households (59'971)
- Persons (62'868)
- Stages (310'193)
 - Car/mc > 3km with 2 way-points
 - Railway connections with HAFAS
 - Recruitment of the SC-experiments (IVT)

- CATI with multiple calls (no incentives) (72% response rate)
- Recruitment for the SC: 50% willingness
- Customized SCs for 85% of the recruited within 12 days
- 70% response rate for the SC experiments

Research and development needs: Diaries

- Integration of the "non-chosen" alternatives (Routes, transit service levels, flight costs, etc.)
- Trade-off between incentive and participation ("young men with smatz phones only")
- Integration of relevant and standaridsed scales (Environment, risk, variety seeking)
- Integration of social networks
- Integration of multi locality

Why social networks in transport/spatial planning?

Example: Number of accompanying travellers



Example: Required travel for leisure meetings of ego-alter



Distance between home locations [km]

Location choice

- WTP
- Taste
- Joint choice with family, friends, persons to meet
- Schedule constraints
- Social constraints

For mode choice in addition

- Luggage
- Company

Example: Residential location choice in Kt. Zürich

Variable	Beta	t-Test
Rent/Income	-5.51	***
log(m2/head)	0.98	***
Frequency weighted mean distance to friends	-8.16	*
Exponent (friends)	0.22	**
Mean distance to work/school	-1.59	**
Exponent (distance to work)	0.37	**
Travel time to Bürkliplatz	0.02	**
log(transit accessibility) * "No car"	0.41	**
log(car accessibility) * "Car"	-0.30	**
Share of equally sized HH within 1 km	0.02	*
Population density within 1 km	0.01	**
Share of empty flats in municipality	-0.11	
N= 683, rho² = 0.2128; * > 0.1; ** > 0.05; *** > 0.01		

Benchmarking the current state

- Numbers of contacts
- Distance distributions
- Geographies
- Frequency and mode of contact
- "Productivity"
- Levels of local anomie
- Levels of local trust
- Level of place attachment
- Surveys of social geographies & mobility biographies
 - Egocentric
 - Snowball
- Travel diaries
 - One-Day
 - Multple days
 - With/without information about the presence of others
 - With/without named co-travellers, co-present persons

- Ohnmacht: 50 egos qualitative/quantitative in Zürich
- Larsen/Urry: 24 egos qualitative/quantitative in NE England
- Frei: 300 egos quantitative in Zürich
- Kowald: snowball; 750 egos quantitative worldwide (starting with 40 egos in Kanton Zürich)(12000 alters in total) (8 day diary included)

Number of contacts reported





Frei and Axhausen, 2007

Great circle distances between "leisure" contacts



Example of a social network geography





Interactions by mode and distance between homes



Frei and Axhausen, 2007

Challenges:

- Start with representative seeds
- Avoid selection bias
- React to homogeneous clusters
- Correct the overrepresentation of ,socializers' and underrepresentation of ,isolates'



Response rate and response burden (IVT surveys)



Kowald and Axhausen, 2011

Behind egos' horizons: The connected 'snowball'-graph



	Vertices	Edges	Density	Components	Triangles
Without sociogram	6'584	7'349	0.000	19	0.017
With sociogram	6'584	32'671	0.002	19	0.518

Comparisons

East York, Ontario (Wellman, Carrasco et al.)

Eindhoven, Netherlands (Arentze, Van der Berg)

Concepcion, Chile (Carrasco)

City of Zürich (Frei)

Kanton Zürich snowball (Kowald)



Shares of contact by mode



Multi-locality: Multiple reference points

- Parental "home"
- "Home"
- Student digs
- Pied-a-terre
- Company dormatory
- Hotel (chain)
- Weekend home(s) (of others)
- RV (camp ground) (of others)
- Living apart together

GPS self-tracing

Capurted with	Where	What
GPS logger	Cincinatti, OH	Regional transport study; purpose imputation (Ohio DOT)
	Jerusalem	Regional transport study; (Israel DOT)
	Kanton Zürich	Transit route choice (IVT, ETH)
Smartphones	Singapore	Capturing activities within and without building (SMART)
	Bay Area	Capturing trips (Joan Walker and UC Berkeley Kollegen)

COST and peacox 7th framwork project: GPS based diary at IVT

GPS unit:

- Interval: 1Hz
- 3D position
- Date and time
- HPOD and other measures of accuracy
- Accelerometer
 - Interval 10 Hz
 - 3D accelleration

Battery

• Multiple days

GSM:

 Savings every 4 hours on SQL database server



GPS-based prompted recall survey

300 participant for 7 days

Web-survey

- Socio-demographs
- Attitudes to risk, environment, variety seeking
- Checking and correction of the automated processing

1. Aktivitäten 2. Wege

Bitte korrigieren und ergänzen Sie das Verkehrstagebuch. Korrigieren Sie erst die Aktivitäten und dann die Wege. Hilfestellungen finden Sie auf der **Startseite**.



Data processing



Filtering and smootinh

Filtering

- VDOP > 5
- Unrealististic elevations
- Jumps with v > 50m/s

Smoothing

- Gauss Kernel smoother over the time axis
- Speed as first derivate of the positions
- Raw data are kept



Detection of stages and stops

Clusters of high density

Longer breaks without points

- Accelerometer data
- GPS points

No movement

- $V \approx 0 \text{ km/h}$
- No accellerations

Mode change

• Walk stage as signal



Number of trips/day in comparison with MZ 2005



Trip durations and length in comparison with MZ 2005



Quelle: Schüssler, 2010 (ohne Beschleunigungsdaten

	ZH	WI	GE	MZ 2005
Number of persons	2 435	1 086	1 361	2 940
Days per persons	6.99	5.96	6.51	1
Trips per day	4.50	3.40	4.26	3.65
Trip lengths [km]	7.72	7.37	7.19	8.79
Daily trip lengths [km]	34.74	23.20	29.25	32.13
Trip duration [min]	15.17	13.71	15.05	26.21
Stages per day	1.40	1.31	1.47	1.68

Mode detection



Trip length by mode in comparison with MZ 2005



Map matching

Car and bike stages

Selection from a set of possible routes

- At nodes all possible on-going links become new candidate routes (branches)
- If the tree has enough branches, it is pruned based on their total errors

Each candidate branch is assessed by

- Squared error between GPS and path
- Deviation between GPS speed and posted speeds

Transit-stages

- Route identified as for cars
- Line identified by time table





Map-Matching: Number of branches against computing times



- Test dataset with true values
- Automatic calibration of the fuzzy logic parameters
- Further integration between map-matching and mode detection
- Integration of the logic of the stage mode sequences
- Better imputation of the movement during signal loss
- More and better purpose imputation (POI data base; land use data; frequency over multiple days)

- Rate of usable addresses
- Recruitment rate
- Response rate
- Rate of usable returns
- Correlation between household members
- Correlation between days
- Correlation between tours of a day
- Correlation between trips of tour
- Number of waves with the GPS loggers
- Rate of loss of the GPS loggers

	Diaries	GPS-self tracing		
Advantages	All variables	All movements (but data loss)		
	Social contacts	Exact times, routes, locations		
		Longer observation periods		
Dis- advantages	≈15% under reporting of trips	Post-processing and imputation		
	Rounded times	(Effort of the post-processing)		
	Approximate routes only			
	Decreasing response rates / expensive response	Unknown response rates (Costs of the units and their distribution/collection)		
www.ivt.ethz.ch

www.matsim.org

www.futurecities.ethz.ch

- Arentze, T.A., M. Kowald and K.W. Axhausen (2012) A method to model population-wide social networks for large scale activity-travel micro-simulations, paper presented at the 91th Annual Meeting of the Transportation Research Board, Washington, D.C., January 2012
- Axhausen, K.W. (2000) Geographies of somewhere: A review of urban literature, *Urban Studies*, **37** (10) 1849-1864.
- Axhausen, K.W. (2008) Social networks, mobility biographies and travel: survey challenges, *Environment and Planning B*, **35** (6) 981-996.
- Axhausen, K.W. (2007) Activity spaces, biographies, social networks and their welfare gains and externalities: Some hypotheses and empirical results, *Mobilities*, **2** (1) 15-36.
- Axhausen, K.W. and A. Frei (2007) Contacts in a shrunken world, *Arbeitsbericht Verkehrs- und Raumplanung*, **440**, IVT, ETH Zürich, Zürich.
- Botte, M. (2003) Strukturen des Pendelns in der Schweiz, Diplomarbeit, Fakultät für Bauingenieurwesen, TU Dresden, August 2003.

- Frei, A. and K.W. Axhausen (2011) Collective location choice model, paper presented *Arbeitsberichte Verkehrs- und Raumplanung*, **686**, IVT, ETH Zürich, Zürich
- Frei, A. and K.W. Axhausen (2007) Size and structure of social netowork geographies, *Arbeitsberichte Verkehrs- und Raumplanung*, **439**, IVT, ETH Zürich, Zürich.
- Dicken, P. (1998) *Global Shift: Transforming the World Economy*, Paul Chapman Publishing, London.
- FCC (2001) Long distance telecommunication industry, FCC, Washington, D.C.
- Grannis, R. (1998) The importance of trivial streets: Residential streets and residential segregation, *American Journal of Sociology*, **103 (**6) 1530-1564.
- Kowald M. and K.W. Axhausen (2011) Surveying data on connected personal networks, Arbeitsberichte Verkehrs- und Raumplanung, 722, IVT, ETH Zürich, Zürich.
- Larsen, J., J. Urry and K.W. Axhausen (2006) *Mobilities, Networks, Geographies*, Ashgate, Aldershot.
- Putnam, R.D. (1999) *Bowling Alone: The collapse and revival of American community*, Schuster and Schuster, New York.
- Schlich, R., B. Kluge, S. Lehmann und K.W. Axhausen (2002) Durchführung einer 12-wöchigen Langzeitbefragung, *Stadt Region Land*, **73**, 141-154.