Social networks and the dynamics of travel

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IVT
ETH
Zürich

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Acknowledgements

Social networks:
- Timo Ohnmacht, Andreas Frei
- Matthias Kowald
- Lijun Sun
- Andreas Diekmann, ETH Zürich
- Jonas Larsen, Roskilde/John Urry, Lancaster
- Terasa Tan, Vincent Chua, NUS, Singapore

Agent-based models
- Thibaut Dubernet
- Pieter Fourie

Social network generation
- Theo Arentze, TU Eindhoven
Acknowledgements

Most of the materials and more is in:

Why the interest?
An agent-based model of travel demand: e.g. Singapore
Avg. daily distance travelled by income tercile (1980 – 2010)

Daily distance travelled [%]

Average Cohort Age [Years]

1910-29
1930-39
1940-49
1950-59
1960-69
1970-79
1980-89
1990-99
Before 1910

3rd Tercile
2nd Tercile
1st Tercile

Marmolejo and Ciari, 2013
Car always available (Switzerland 1980 – 2010)
Road based – Switzerland 1950 and 2000

Scherer, 2004
Leisure travel in the 2000’s

<table>
<thead>
<tr>
<th>Trip purpose</th>
<th>Switzerland</th>
<th>Germany</th>
<th>UK</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leisure</td>
<td>40.2</td>
<td>17.4</td>
<td>41.0</td>
<td>9.4</td>
</tr>
<tr>
<td>Work/School</td>
<td>36.5</td>
<td>57.0</td>
<td>32.0</td>
<td>33.5</td>
</tr>
<tr>
<td>Shopping/Private business</td>
<td>12.8</td>
<td>15.9</td>
<td>12.0</td>
<td>11.9</td>
</tr>
<tr>
<td>Escorting others</td>
<td>4.8</td>
<td>9.7</td>
<td>15.0</td>
<td>-</td>
</tr>
<tr>
<td>Others</td>
<td>5.7</td>
<td>-</td>
<td>-</td>
<td>45.2</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>
### Long distance journeys (100km+) in Germany, 2010’s

<table>
<thead>
<tr>
<th>Type</th>
<th>Number/year</th>
<th>km/journey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacation (5 days plus)</td>
<td>1.0</td>
<td>1600</td>
</tr>
<tr>
<td>Short vacation (2-4 days)</td>
<td>1.2</td>
<td>410</td>
</tr>
<tr>
<td>Other journeys with overnight stays</td>
<td>0.3</td>
<td>410</td>
</tr>
<tr>
<td>Day excursions</td>
<td>6.0</td>
<td>200</td>
</tr>
<tr>
<td>Business trip with overnight stay</td>
<td>1.2</td>
<td>500</td>
</tr>
<tr>
<td>Business trip without overnight stay</td>
<td>1.2</td>
<td>150</td>
</tr>
<tr>
<td>Long-distance commuting and other trips</td>
<td>5.0</td>
<td>150</td>
</tr>
</tbody>
</table>
Why social networks in transport/spatial planning?
Example: Number of accompanying travellers

- Short vacation
- Excursion: nature
- Other
- Excursion: culture
- Meeting friends
- Further education (leisure)
- Garden/ cottage
- Voluntary work
- Disco, pub, restaurant, cinema
- Meeting relatives/family
- Window shopping
- Pick up/drop off/attendance
- Group/club meeting
- Family duty
- Cemetery
- Active sports
- Education
- Long-term shopping
- Walk or stroll
- Daily shopping
- Private business
- Private business (doctor,...)
- Work

Axhausen et al., 2007
Example: Required travel for leisure meetings of ego-alter

Distance between home locations [km]

<table>
<thead>
<tr>
<th>Distance</th>
<th>Percent [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 10 km</td>
<td>30</td>
</tr>
<tr>
<td>10 - 20 km</td>
<td>40</td>
</tr>
<tr>
<td>20 - 30 km</td>
<td>50</td>
</tr>
<tr>
<td>40 - 50 km</td>
<td>20</td>
</tr>
<tr>
<td>60 - 250 km</td>
<td>10</td>
</tr>
<tr>
<td>Abroad</td>
<td>0</td>
</tr>
</tbody>
</table>

Important contact

- Yes
- No

Schlich et al., 2002
Example: Heterogenity in choice

Location choice

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

For mode choice in addition

• Luggage
• Company
• Weather
• Temperature
## Example: Residential location choice in Kt. Zürich

<table>
<thead>
<tr>
<th>Variable</th>
<th>Beta</th>
<th>t-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rent/Income</td>
<td>-5.51</td>
<td>***</td>
</tr>
<tr>
<td>log(m2/head)</td>
<td>0.98</td>
<td>***</td>
</tr>
<tr>
<td><strong>Frequency weighted mean distance to friends</strong></td>
<td>-8.16</td>
<td>*</td>
</tr>
<tr>
<td>Exponent (friends)</td>
<td>0.22</td>
<td>**</td>
</tr>
<tr>
<td>Mean distance to work/school</td>
<td>-1.59</td>
<td>**</td>
</tr>
<tr>
<td>Exponent (distance to work)</td>
<td>0.37</td>
<td>**</td>
</tr>
<tr>
<td>Travel time to Bürkliplatz</td>
<td>0.02</td>
<td>**</td>
</tr>
<tr>
<td>log(transit accessibility) * &quot;No car&quot;</td>
<td>0.41</td>
<td>**</td>
</tr>
<tr>
<td>log(car accessibility) * “Car&quot;</td>
<td>-0.30</td>
<td>**</td>
</tr>
<tr>
<td>Share of equally sized HH within 1 km</td>
<td>0.02</td>
<td>*</td>
</tr>
<tr>
<td>Population density within 1 km</td>
<td>0.01</td>
<td>**</td>
</tr>
<tr>
<td>Share of empty flats in municipality</td>
<td>-0.11</td>
<td></td>
</tr>
</tbody>
</table>

\[ N= 683, \rho^2 = 0.2128; * > 0.1; ** > 0.05; *** > 0.01 \]
Travel and social networks
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
Empirical strategy

- Surveys of social geographies & mobility biographies
  - Egocentric
  - Snowball

- Travel diaries
  - One-Day
  - Multiple days

- With/without information about the presence of others
- With/without named co-travellers, co-present persons
Social network surveys @ IVT

- Ohnmacht: 50 egos qualitative/quantitative in Zürich
- Larsen/Urry: 24 egos qualitative/quantitative in NE England
- Frei: 300 egos quantitative in Zürich
- Tan, Chua: 411 egos using 11 prompts
- Kowald: snowball; 750 egos quantitative worldwide (starting with 40 egos in Kanton Zürich) (12000 alters in total) (8 day diary included)
- Kowald/Diekmann: 2000 respondents of the Swiss Environment Survey – 5 core alters
- Sun: Smart card use on busses in Singapore
Biography of an architect, about thirty

National Links

Friend always known
Phone weekly
Email daily
Text weekly
Meet up weekly
Walking distance

Mother
Phone everyday
Never email or text
Meet up weekly
Walking distance

Workmate
known '04
Phone weekly
Email weekly
Text weekly
Meet up every day at work in Liverpool

Sister
Phone monthly
Email monthly
Text monthly
Meet up monthly
Train is £38, 4.29 hours, 4 changes.

School friend
Phone monthly
Email daily
Text weekly
Meet up every 3 months
Train is £32, 3 hr 12 min

International Ties

University friend
Phone every 3 month
Email daily
Never text
Meet up yearly
Flight is £639, 16 hr 45 min

Key To Symbols

- Place of Residence
- Most Significant People
- Other Friends and Family
- Former Places of Residence

Larsen, Urry and Axhausen, 2006
Number of contacts reported

Percent

Number of contacts named

Frei and Axhausen, 2007
Great circle distances between “leisure” contacts: Zürich
Great circle distances between “leisure” contacts: Snowball

Daten: Schneeballbefragung IVT, Siehe Kowald et al. 2012
Example of a social network geography
Size of network geometries

95%-confidence ellipse of the social network geography

Frei and Axhausen, 2007
Interactions by mode and distance between homes

Frei and Axhausen, 2007
Singapore 2014, some few new results
Singapore 2014, mean distance to alters

![Diagram showing mean distance to alters by age groups](image-url)
2010/11 Snowball survey
Response rate and response burden (IVT surveys)

- Prior recruitment and incentive (solid line)
- Prior recruitment, no incentive (dashed line)
- No prior recruitment, no incentive (dashed-dotted line)

Kowald and Axhausen, 2011
Behind egos’ horizons: The connected ‘snowball’-graph

<table>
<thead>
<tr>
<th></th>
<th>Vertices</th>
<th>Edges</th>
<th>Density</th>
<th>Components</th>
<th>Triangles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without sociogram</td>
<td>6'584</td>
<td>7'349</td>
<td>0.000</td>
<td>19</td>
<td>0.017</td>
</tr>
<tr>
<td>With sociogram</td>
<td>6'584</td>
<td>32'671</td>
<td>0.002</td>
<td>19</td>
<td>0.518</td>
</tr>
</tbody>
</table>

Seed
Ego
Bridging alter

Kowald and Axhausen, 2011
Comparisons
Transport motivated social network surveys

- East York, Ontario (Wellman, Carrasco et al.)
- Eindhoven, Netherlands (Arentze, Van der Berg)
- Concepcion, Chile (Carrasco)
- City of Zürich (Frei)
- Kanton Zürich snowball (Kowald)
Contact “density” – shares by distance class
Shares of contact by mode

**Face-to-face**

![Graph showing the share of face-to-face contacts by great circle distance in kilometers.](image)

**Telephone**

![Graph showing the share of telephone contacts by great circle distance in kilometers.](image)

**Internet**

![Graph showing the share of internet contacts by great circle distance in kilometers.](image)
Low level networks as a building block
Smart card records as a source

- **Boarding Stop ID**
  - Card ID,
  - Passenger Type,
  - Travel Mode,

- **Bus**
  - Service Number,
  - Ride Start Time (Date),
  - Bus Registration No.
  - Direction

- **Alighting Stop ID**
  - Ride Duration,
  - Ride Distance,
  - Fare Paid,

- **Metro**
  - Transfer Number,
  - Boarding Station ID,
  - Ride Start Time (Date),
  - Ö
Arrival distribution along a line
Number of contacts versus usage frequency

Sun et al., 2013
... Friday
... the weekly summary
A small world network in Singapore‘s busses

• One component by Wednesday

• Diameter: 6

• Characteristic path length: 2.95
  • (random: 2.63)

• Average clustering coefficient: 0.19
  • (random: 4.5x10⁻⁴)

• Small-world
A small world network in Singapore‘s busses, but uneven

Median of x coordinate

Median of y coordinate

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Integration
Integration and future work

• Generation of artificial social networks (Arentze et al., 2012) (degree, clustering, distances)

• Repeat of Switzerland Snowball

• Measurement of network size (leisure, work, civic engagement)

• Measurement of network dynamics (Timmerman’s ERC project, Carrasco’s Concepcion survey)

• Measurement of anomie, trust and social network geography

• Integration of network choice/decision making model (Dubernet)
Integration, again
Some hypotheses for travel behaviour and more

Wages
- Fleet comfort
  + Activities
  + Tours
  + Energy costs
  + vkm
  - vtt's et al.

Housing consumption
- Professional and personal activity space
  - Number of networks
  - Network overlap
  - Local anomie

Specialisation
- Migration
- Network geography

Elasticity > 0
Elasticity < 0
Questions?

www.ivt.ethz.ch

www.matsim.org

www.futurecities.ethz.ch


