Activity-based mobility modeling: overview and research topics

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Outline

• Activity-based modeling – overview

• Rotterdam case study – illustration of an application

• Current research topics

• Examples of exploring new area
  • Mental representations and choice behavior
  • Group decision making in joint activity choice

• Conclusions
Travel demand models

- Micro simulation models
  - Activity-based models
    - Daily activity-patterns
  - Tour-based models
    - Trip records
- Aggregate models

OD trip matrix

Dynamic/static traffic simulation/assignment models

Predicting people’s response to policies is notoriously difficult
Travel demand models

Micro simulation models

Activity-based models

Daily activity-patterns

Trip records

Trip/tour-based models

Aggregate models

OD trip matrix

Dynamic/static traffic simulation/assignment models

New model development started in early nineties

Models are now making the transition to practice
The activity-based approach
### Activity-based versus trip-based approach

<table>
<thead>
<tr>
<th>Trip-based</th>
<th>Activity-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus is on trips</td>
<td>Focus is on activities</td>
</tr>
<tr>
<td>Unit is a trip</td>
<td>Unit is a day</td>
</tr>
<tr>
<td>Space-time constraints ignored</td>
<td>Space-time constraints taken into account</td>
</tr>
<tr>
<td>Low resolution time and place</td>
<td>High resolution time and place</td>
</tr>
<tr>
<td>Decision unit is individual</td>
<td>Decision unit is household</td>
</tr>
<tr>
<td>Predicts when, where, transport mode</td>
<td>Predicts which activities, when, where, for how long, trip-chaining and transport mode</td>
</tr>
</tbody>
</table>
Advantages of the activity-based approach

• Better predictions

• Sensitivity to broader range of policy scenarios

• Higher level of precision in time and space

• Transparency – models tell the full story
Approaches

• **Constraints-based**
  • Stems from time geography (Hagerstrand)
  • Basic concept is space-time prisms
  • Purpose is accessibility analysis – not prediction
  • Examples: Carla, Mastic

• **Nested-logit models**
  • Extension of trip and tour-based models
  • Started with the work of Bowman and Ben Akiva (2001)
  • Rather course classification of activities and modes
Approaches - continued

- **Activity-scheduling models**
  - Take scheduling process and constraints into account
  - Utility-based models versus rule-based models
  - Some pioneering models
    - Famos, Albatross, Cemdap, Tasha, Adapts

- **Simulation / optimization models**
  - Traffic oriented models (Transims, Matsim)
  - Operations Research models (Happs)
  - Supernetwork models
Rotterdam case study
Liao, F., T. Arentze, E. Molin, W. Bothe

Illustration of an application
An activity-based supernetwork model
Study area delineation
Synthetic population

Corridor: 2.5 million residents (2009)

Total: 21,117 agents

Activity programs were taken from a survey

Agents : Residents = 1 : 118
Activity programs

Average per person
- 2.46 activities per day
- 1.57 tours per day

<table>
<thead>
<tr>
<th>#trips</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>&gt;7</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>47%</td>
<td>7.3%</td>
<td>26%</td>
<td>4.9%</td>
<td>9.1%</td>
<td>2.5%</td>
<td>3.0%</td>
</tr>
</tbody>
</table>
P + R locations

- P+R locations (9 in R’dam)
- Train stations (10 locations)
- Actual tariffs
Public transport upgrades

New tram line has stop in Rdam stadion station
High frequent trains between Randstad cities
Increase parking price at activity locations

Parking costs double
Spatial developments – realistic

- Shopping
- Going out
- Culture
- Sports
Spatial developments – city center

- Shopping
- Going out
- Culture
- Sports

All concentrate in city center
Spatial developments – near nodes

- Shopping
- Going out
- Culture
- Sports

Concentrate near transport nodes
Example of a case

An individual lives North-east of center and has a *non-daily shopping* activity on the agenda.
Example of a case

The person considers five options - three close to home and the other two in Rotterdam center.
Example of a case

Before spatial development, the person always takes bike and does shopping at the same postcode area.
Example of a case

After city center investment, the person switches to use car, parks car at P+R *Capselse brug* and then takes PT to center.
Total costs (disutility) of implementing activities

PT upgrades improve utility

City scenario biggest utility improvement

Parking price increase causes strong decline in utility
Total car kilometers

PT upgrades no influence

With Park car kilometers decrease

With Real car kilometers increase

With City car kilometers decrease
Number of people making use of P+R

- Park – strong increase P+R
- City causes decrease in P+R use
- More often entire trip by PT
- Node leads to most P+R use
P+R use – for which activities?

Used most often for working and shopping trips

Work trips react more strongly to parking price

Spatial development has an impact

PT upgrades have minor impact
Conclusions

• Integrated approach
  • Spatial development / Transportation / Pricing
  • Multimodal networks
  • Preferences (utilities)
  • Complete activity programs

• Transparancy
  • Individual approach
  • Very high degree of detail
Current research topics
# Advancements in survey technology

<table>
<thead>
<tr>
<th>Traditional – diary data</th>
<th>New – GPS tracking</th>
</tr>
</thead>
<tbody>
<tr>
<td>One or two days data</td>
<td>Longer time frame – week or multiple weeks</td>
</tr>
<tr>
<td>Location identification is difficult and imprecise</td>
<td>Location identification is automated and precise</td>
</tr>
<tr>
<td>No recording of travelled routes</td>
<td>Recording of travelled routes</td>
</tr>
<tr>
<td>User unaided in memorizing of activities and modes</td>
<td>Automated interpretation + prompted recall</td>
</tr>
</tbody>
</table>
Automated interpretation - example

Bayesian classifier approach (Moiseeva, Jessuran, Timmermans 2010)
Research agenda – activity-based modeling

• Dynamic traffic modeling
  • Integration of ABM and traffic modeling

• Dynamic activity-based modeling
  • Extending the time frame from 1 day to multiple days
  • Including life trajectories
    – Long-term mobility decisions
    – Life-course events

• Integrated land-use and travel demand modeling
  • ABMs replace trip-based models
Research agenda – activity-based cont’d

• Social networks and social interaction
  • From isolated to interconnected agents
  • From independent to group decision making

• Quality of life
  • Subjective wellbeing
  • Health
Trends and developments in society

• ICT revolution
  • Social media
  • Augmented reality
  • Mobile traveler information systems
  • Flexible work times and work places

• New modes of transport
  • Electrical vehicles (bicycles, cars)
  • Car sharing
  • Multi-modal transport networks
Trends and developments in society – cont’d

• New modes of traffic management
  • Individual / personalized

• New requirements and concerns
  • Ageing population
  • Transition to renewable forms of energy
  • Urbanization – scarcity of space
  • Quality of life – air quality, health, mobility
Bounded rationality

Habitual life
Learning & judgment

Rational beliefs
versus
Emotional weighting and memory bias

Exploration
Search & info acquisition

No search costs
versus
Sequential search and satisficing behavior

Choice
Evaluation & decision

Absolute utility values
versus
Reference-based utilities and emotional weighting

Activity and mobility patterns & perceived wellbeing

Needs and resources
- ICT tools
- Social network
- Physical - ICT
- Institutional
- Prices
- Technological

Independent decisions
versus
Social influence and group decision making

Decision utility
versus
Experienced utility
A research program on bounded rationality

- Learning and judgment
  - Replace Bayesian inference models
- Exploration
  - Replace full information / unlimited search models
- Choice making
  - Replace absolute utility models
- Subjective wellbeing
  - Replace current decision utility models
- Social influence and decision making
  - Replace current independent / group models

Prerequisite is to move from static to dynamic models
Time is ripe

• Cumulative evidence from psychology and behavioral economics
  • See recent book of Daniel Kahneman

• Human biases are well documented and tools for data collection and modeling available

• Modern survey technologies facilitate a move from one-day to multiple days data collections

• Wide use of smart phones allows real-time interactive data collection methods
Example of exploring new area (1)

What’s in a person’s mind?

Individuals’ mental representations of complex choice problems

Joint work with Benedict Dellaert, Erasmus University Rotterdam
Booking a fun holiday....

with children
A causal network model of mental representations

Differences in mental representations lead to differences in evaluations of choice alternatives
Example - shopping

- Location
  - Crowded
  - Prices
  - Store variety
  - Pleasant
  - Goal success

- Transport mode
  - Travel time
  - Transfers

- Convenience

Utility

Decisions
- Attributes
- Benefits
Example - shopping

Location
  - Crowded
  - Prices
  - Store variety

Transport mode
  - Travel time
  - Transfers

Utility
  - Goal success
  - Convenience

Decisions
Attributes
Benefits
# Comparison to standard model

<table>
<thead>
<tr>
<th>Standard model</th>
<th>New approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attributes of alternatives are assumed as given</td>
<td>Attribute selection is part of the model</td>
</tr>
<tr>
<td>No information about underlying reasons</td>
<td>Benefits underlying attribute evaluation are part of the model</td>
</tr>
<tr>
<td>Mental costs of evaluation are not taken into account</td>
<td>Mental costs of evaluation are taken into account</td>
</tr>
<tr>
<td>Data about attributes are collected in focus groups</td>
<td>Mental representations are measured by a special purpose interview technique</td>
</tr>
<tr>
<td><strong>Hybrid choice model</strong></td>
<td><strong>New approach</strong></td>
</tr>
<tr>
<td>------------------------------------------------------------</td>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td>Psychological factors are taken into account as latent variables</td>
<td>Mental representations are taken into account</td>
</tr>
<tr>
<td>Psychological factors are attitudes or perceptions influencing preferences</td>
<td>Mental representations are causal networks for reasoning about a choice problem</td>
</tr>
<tr>
<td>Psychological factors are stable person characteristics</td>
<td>Mental representations are activated in a situation</td>
</tr>
</tbody>
</table>

**Comparison to hybrid choice model**
Measurement of MRs

- CNET – interview technique of open-response elicitation

Example

- Imagine a situation where you plan to make a shopping trip

- When you choose between Car, Bus and Bike
  - What are your considerations?
  - Why is it important?

- What would you choose?

In contrast to existing laddering techniques – CNET is decision oriented
Wat overweegt u?

We bekijken nu de tweede beslissing: keuze van tijdstip van boodschappen doen.
Weet u nog: voor deze beslissing heeft u drie opties:

1. Tijdens de lunch pauze
2. Na het werk
3. 'Avaoda

U heeft een voldoende baan. Alleen wat u wilt kopen is het hele dag beschikbaar.

Wat zijn uw overwegingen als u een keuze moet maken uit deze drie opties?

Het is belangrijk dat u alle overwegingen boodschappen met deelst een overweging neemt. Druk op DOORGAAN als u alle overwegingen heeft aangegeven.

U heeft ingetoetst:

of er drukte op de weg is

Hieronder staan bewoordingen uit onze database. Selecteer u alstublieft de suggestie die het dichtst bij uw overweging komt en kijk daarna op DOORGAAN. Als meerdere suggesties van toepassing zijn, dan kunt u die later nog overwegen.

- Drukte op de weg
- Drukte op het werk
- Anders

Wijzig  
Doorgaan

Universiteit van Tilburg

Belasting voor milieu
- Ontspanning
- Veiligheid van de verplaatsing
- Gemak van de verplaatsing
- Reisplezier
- Tijdsbesparing
1. Basic building block is a D – A – B chain

2. Value of including a D – A – B chain
   • *Gain*: reduction of risk of making wrong decision
   • *Costs*: mental effort required for including in evaluation

3. Risk of making the wrong decision
   • Utility variance caused by the decision variable
Logit model of MR activation

Net utility of activating a D-A-B chain in situation $n$

$$u_{hijnc} = \alpha_{jn} \cdot s^{ijn} \cdot s^{hin} \cdot sd(r^{hijn}) - \theta_n + \varepsilon_{hijnc}$$

Probability of activating a D-A-B chain follows binary logit specification

Extended to allow for heterogeneity in mental costs ($\theta_{nc}$) and base line alternative preferences.
Empirical application (Horeni et al. 2010)

• Representative sample of 666 individuals from a Dutch panel

• Scenarios
  • Base
  • Uncertainty - product availability and travel time
  • High Consequences - boss over for dinner

• Respondents were randomly allocated to a scenario
Considerations in deciding *where* to shop, *when* to shop, and *which* transportation to use.

<table>
<thead>
<tr>
<th>Destination</th>
<th>Walk (min)</th>
<th>Bicycle (min)</th>
<th>Car (min)</th>
<th>Bus (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home-neighborhood center</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Home-regional shopping center</td>
<td>35</td>
<td>15</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Home-work</td>
<td>50</td>
<td>20</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Home-city center</td>
<td>25</td>
<td>9</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Work-city center</td>
<td>25</td>
<td>9</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Work-regional shopping center</td>
<td>35</td>
<td>12</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>City center-regional shopping center</td>
<td>25</td>
<td>9</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>City center-parking 1+2</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Times and products uncertain (yes, no)
Example of an MR

- Weather
- Transport mode choice
- Choice of shopping time
- Choice of grocery store

Legend:
- Decision Variable
- Situational variable
- Attribute
- Benefit

Causal link:
- Trip convenience
- Reduced time pressure
- Low effort shopping
- Number of stores
- Available time to shop
- Crowdedness in stores
Some substantive findings

• Most important considerations in scheduling the shopping trips are
  − Shopping success, travel ease, time savings, shopping ease, and financial savings

• Situational conditions varied have
  − Little influence on attributes activated
  − Significant influence on
    − Relative importance of the benefits and
    − Some influence on how attributes influence benefits

• Considerable variation exists between individuals in terms of their mental costs in the formation of mental representations
Conclusions

- Mental representations of choice problems can be modeled consistent with utility-based theories of choice and mental-model theories of cognition

- The model captures:
  - Perceived importance of benefit variables
  - Perceived strength of causal relationships
    - Decision variables and attributes
    - Attributes and benefits
    - Mental cost differences between individuals

- Situation variation allows for fit with key usage contexts
  - Input for situation targeted communication and decision support
Joint activity choice

The role of fairness and asymmetric evaluation of costs and rewards
# Modeling joint activity choice

<table>
<thead>
<tr>
<th><strong>Standard model</strong></th>
<th><strong>New approach</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactions between persons within households</td>
<td>Extended to social networks of persons</td>
</tr>
<tr>
<td>Assumes a group utility function</td>
<td>No group utility function, just individual preferences</td>
</tr>
<tr>
<td>Ignores the process of group decision making</td>
<td>Assumes a negotiation process</td>
</tr>
<tr>
<td>Rational model</td>
<td>Bounded rationality – human biases</td>
</tr>
</tbody>
</table>
Two-players ultimatum game

One player proposes a distribution of a fixed amount of money

The other player has the option to either accept or reject the offer

If the person accepts he receives the amount offered; if he rejects he receives nothing

What would be the outcome under the assumption of rationality?

What do people do in these games?
Assume you are planning a joint activity with two friends.

The preferences in the group are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Activity A</th>
<th>Activity B</th>
<th>Activity C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yourself</td>
<td>9</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Friend 1</td>
<td>5</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Friend 2</td>
<td>5</td>
<td>7</td>
<td>9</td>
</tr>
</tbody>
</table>

Which proposal would you do?

- Activity A  \(\text{Maximizes own outcome}\)
- Activity B  \(\text{Maximizes group outcome}\)
- Activity C
Experiment – joint activity choice (2)

Another example

The preferences in the group are as follows

<table>
<thead>
<tr>
<th></th>
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<td>7</td>
</tr>
<tr>
<td>Friend 1</td>
<td>9</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Friend 2</td>
<td>5</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>

Which proposal would you do?
- Activity A
- Activity B
- Activity C

Maximizes group outcome
Equal distribution
Experiment – joint activity choice – variant (1)

This time the travel times differ

The travel times in the group are as follows (minutes)

<table>
<thead>
<tr>
<th></th>
<th>Location A</th>
<th>Location B</th>
<th>Location C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yourself</strong></td>
<td>5</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td><strong>Friend 1</strong></td>
<td>5</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td><strong>Friend 2</strong></td>
<td>25</td>
<td>15</td>
<td>5</td>
</tr>
</tbody>
</table>

Which proposal would you do?
- Location A
- Location B
- Location C

Does this make a difference?
This time one of the friends does a proposal

The preferences in the group are as follows

<table>
<thead>
<tr>
<th></th>
<th>Activity A</th>
<th>Activity B</th>
<th>Activity C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yourself</td>
<td>9</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Friend 1</td>
<td>5</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Friend 2</td>
<td>5</td>
<td>7</td>
<td>9</td>
</tr>
</tbody>
</table>

Friend 1 proposes to do: **Activity B**

What would you do?
- Accept the proposal
- Do another proposal, namely
- Activity A
- Activity C

Does this make a difference?
Social utility function

\[ U_{ik} = \beta_{0k} \cdot I_i + \beta_{1k} \cdot Z_{ik} + \beta_{2k} \cdot \sum_{m \neq k} Z_{im} + \beta_{3k} \cdot D(Z_i) \]

- \( U_{ik} \) is the social utility person \( k \) assigns to option \( i \)
- \( Z_{ik} \) is the preference value person \( k \) assigns to option \( i \)
- \( m \) is an index for the others in the group
- \( Z_i \) is a person-vector of preference values for option \( i \)
- \( D \) is some measure of dispersion (inequality)
- \( I_i \) is a binary variable indicating whether option \( i \) is proposed by a friend
- \( \beta_{0k} \) is relative weight person \( k \) assigns to proposal status
- \( \beta_{1k} - \beta_{3k} \) are relative weights person \( k \) assigns to particular outcomes
Theory

• Under rationality assumption
  • Persons either maximize an own (selfishness), others’ (altruism) or group (neutral) outcome
  • Equality outcomes (fairness) does not play a role
  • Proposal status does not play a role
  • Costs / rewards difference does not play a role

• Hypotheses
  • Fairness plays a significant role
  • Proposal status plays a role (people are cooperative)
  • There is an asymmetry between costs and rewards
Experiment

• 315 persons participated
• Representative sample
• Each person received
  • 8 tasks – 4 x initiating and 4 x responding
• Scenarios
  • Activity versus travel time
  • High versus low consequences
• Outcome tables were varied by an efficient design
# Results – basic MNL model

## Activity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value (β)</th>
<th>t-value (β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-interest ($\beta_1$)</td>
<td>0.532</td>
<td>14.0</td>
</tr>
<tr>
<td>Other ones interest ($\beta_2$)</td>
<td>0.319</td>
<td>11.1</td>
</tr>
<tr>
<td>Inequity ($\beta_3$)</td>
<td>-1.16</td>
<td>-11.9</td>
</tr>
<tr>
<td>Proposal status ($\beta_0$)</td>
<td>0.928</td>
<td>9.21</td>
</tr>
<tr>
<td>Scale - small consequences</td>
<td>1.33</td>
<td>2.15</td>
</tr>
<tr>
<td>Scale - large consequences</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Inequity / self = 2.18

Fairness plays a significant role

Proposal status plays a significant role

## Travel time

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value (β)</th>
<th>t-value (β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-interest ($\beta_1$)</td>
<td>-0.063</td>
<td>-9.55</td>
</tr>
<tr>
<td>Other ones interest ($\beta_2$)</td>
<td>-0.027</td>
<td>-7.01</td>
</tr>
<tr>
<td>Inequity ($\beta_3$)</td>
<td>-0.215</td>
<td>-10.5</td>
</tr>
<tr>
<td>Proposal status ($\beta_0$)</td>
<td>1.58</td>
<td>13.0</td>
</tr>
<tr>
<td>Scale - small consequences</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Scale - large consequences</td>
<td>0.608</td>
<td>-4.72</td>
</tr>
</tbody>
</table>

Inequity / self = 3.40

Fairness has a bigger influence

Proposal status has a bigger influence
### Results – discrete mixture model

#### Activity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mass point</th>
<th>Value (β)</th>
<th>t-value (β)</th>
<th>Probability (π)</th>
<th>t-value (π)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-interest (β₁)</td>
<td>1</td>
<td>1.10</td>
<td>11.3</td>
<td>0.687</td>
<td>10.8</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.062</td>
<td>0.74</td>
<td>0.313</td>
<td>4.94</td>
</tr>
<tr>
<td>Other ones interest (β₂)</td>
<td>1</td>
<td>0.718</td>
<td>8.74</td>
<td>0.777</td>
<td>13.8</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.085</td>
<td>-1.27</td>
<td>0.223</td>
<td>3.95</td>
</tr>
<tr>
<td>Inequity (β₃)</td>
<td>1</td>
<td>0.250</td>
<td>0.85</td>
<td>0.288</td>
<td>4.62</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-2.50</td>
<td>-9.03</td>
<td>0.712</td>
<td>11.4</td>
</tr>
<tr>
<td>Proposal status (β₀)</td>
<td>1</td>
<td>1.17</td>
<td>7.92</td>
<td>0.930</td>
<td>25.7</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5.80</td>
<td>3.73</td>
<td>0.070</td>
<td>1.94</td>
</tr>
</tbody>
</table>

#### Travel time

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mass point</th>
<th>Value (β)</th>
<th>t-value (β)</th>
<th>Probability (π)</th>
<th>t-value (π)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-interest (β₁)</td>
<td>1</td>
<td>-0.020</td>
<td>-1.64</td>
<td>0.525</td>
<td>7.11</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.190</td>
<td>-8.39</td>
<td>0.475</td>
<td>6.43</td>
</tr>
<tr>
<td>Other ones interest (β₂)</td>
<td>1</td>
<td>-0.121</td>
<td>-5.26</td>
<td>0.364</td>
<td>3.46</td>
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<tr>
<td></td>
<td>2</td>
<td>-0.019</td>
<td>-2.11</td>
<td>0.636</td>
<td>6.04</td>
</tr>
<tr>
<td>Inequity (β₃)</td>
<td>1</td>
<td>-0.601</td>
<td>-9.02</td>
<td>0.550</td>
<td>6.74</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-0.079</td>
<td>-1.80</td>
<td>0.450</td>
<td>5.51</td>
</tr>
<tr>
<td>Proposal status (β₀)</td>
<td>1</td>
<td>8.19</td>
<td>5.95</td>
<td>0.261</td>
<td>5.08</td>
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<tr>
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<td>2</td>
<td>1.39</td>
<td>6.98</td>
<td>0.739</td>
<td>14.42</td>
</tr>
</tbody>
</table>

There is considerable heterogeneity
• Balanced style: self & others & equity
• Rational style: self & others
• Selfish style: self
• Social style: equity, equity & self / others
• Else: others; none

Strong asymmetry

Activity
Balanced style dominates

Travel time
Social style dominates
Style memberships: estimation results MNL model

<table>
<thead>
<tr>
<th>Style &amp; Others &amp; Equity</th>
<th>Parameter</th>
<th>Activity Value</th>
<th>t-value</th>
<th>Travel time Value</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self &amp; Others &amp; Equity</td>
<td>Constant</td>
<td>1.67</td>
<td>5.95</td>
<td>-0.762</td>
<td>-2.35</td>
</tr>
<tr>
<td>Self &amp; Others</td>
<td>Constant</td>
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<td>0.19</td>
<td>-0.819</td>
<td>-1.99</td>
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<tr>
<td>age &lt; 35 years</td>
<td></td>
<td>0.230</td>
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<td>-1.37</td>
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<tr>
<td>age 35 -&lt; 55 years</td>
<td></td>
<td>-1.28</td>
<td>-2.49</td>
<td>0.309</td>
<td>0.69</td>
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<tr>
<td>age 55+ years</td>
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<td>1.05</td>
<td>2.94</td>
<td>1.06</td>
<td>2.49</td>
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<tr>
<td>Self</td>
<td>Constant</td>
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<td>-2.13</td>
<td>-0.693</td>
<td>-2.19</td>
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<tr>
<td>Equity +</td>
<td>Constant</td>
<td>0.847</td>
<td>2.75</td>
<td>1.02</td>
<td>4.69</td>
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<tr>
<td>Male</td>
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<td></td>
<td>-0.541</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.541</td>
</tr>
<tr>
<td>Else</td>
<td>Constant</td>
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<td></td>
<td>0</td>
<td></td>
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<td>Adjusted rho-square</td>
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<td>0.207</td>
<td></td>
<td>0.169</td>
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</tbody>
</table>

Older age group more often rational style
Females more often social style in case of travel times
Conclusions

- Considerable heterogeneity in styles
- Bounded rationality
  - Fairness is important
  - Process is important (proposal status)
  - Asymmetry costs and rewards
- Implications
  - People favor compromise solutions for joint activities / travel
  - E.g., they are willing to travel further when this leads to more equal distribution of travel times
- The new model of joint activity choice takes process and human bias into account
Conclusions overall

- Activity-based models show a large diversity of approaches

- New GPS-based survey technology opens up new opportunities

- An important current objective of the field is to develop dynamic models (longer time frames)
Conclusions overall cont’d

• Bounded rationality is important in
  • Learning & judgment
  • Search & information acquisition
  • Decision making
  • Social life

• Examples of exploring new area were given
  • Incorporating mental representations
  • Group decision making in joint activity choice
Activity-based modeling


Survey technology

Mental representations


Joint activity choice


Supernetworks

Thank you for your attention

Questions