Modeling the human dimension of transport

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In a nutshell...

Infrastructures & Vehicles

Travelers & Goods
In a nutshell...

Supply

Demand
Travel demand

- Most people don’t travel for the sake of it
- Travel demand = derived demand
- Results of many choices:
  - Choice of activity
  - Choice of destination
  - Choice of departure time
  - Choice of transportation mode
  - Choice of access point (parking, bus stop)
  - Choice of itinerary
  - Etc...
Choice...

- « It is our choices that show what we truly are, far more than our abilities »
  Prof. Albus Dumbledore

- « Liberty, taking the word in its concrete sense, consists in the ability to choose »
  Simone Weil

- « for his development of theory and methods for analyzing discrete choice”
  Nobel Committee to Daniel McFadden, 2000
Route choice for car drivers
Route choice for car drivers

- **Assumption #1**: drivers prefer the fastest route
- **Warning**:  
  - Their presence affects the other drivers  
  - More cars = increased travel time
- **So...**  
  - Travel time influences route choice  
  - Route choice influences travel time
A simple example

\[ x : 10^3 \text{ veh/h} \]
\[ t : \text{time} \]

\[ t = 50 + x \]

\[ t = 10x \]

6000 veh/h

6000 veh/h
A simple example

\[ x : 10^3 \text{ veh/h} \]
\[ t : \text{time} \]

Left-top: \( t = 83 \)
Bottom-right: \( t = 83 \)

Equilibrium

\[ t = 50 + x \]
\[ x = 3 \]
\[ t = 53 \]

\[ t = 10x \]
\[ x = 3 \]
\[ t = 30 \]

6000 veh/h
A simple example

\[ x : 10^3 \text{ veh/h} \]
\[ t : \text{time} \]

\[ t = 50 + x \]
\[ t = 10 + x \]

\[ t = 1000 \text{ veh/h} \]

\[ t = 50 + x \]
A simple example

\( x : 10^3 \text{ veh/h} \)
\( t : \text{time} \)

Left-top: \( t = 83 \)
Bottom-right: \( t = 83 \)
New path: \( t = 70 \)

No more equilibrium

\( t = 50 + x \)
\( x = 3 \)
\( t = 53 \)

\( t = 10x \)
\( x = 3 \)
\( t = 30 \)

\( t = 10 + x \)
\( x = 0 \)
\( t = 10 \)

\( t = 50 + x \)
\( x = 3 \)
\( t = 53 \)
A simple example

\[ x : 10^3 \text{ veh/h} \]

\[ t : \text{time} \]

1000 veh change
Left-top → new path

Left-top: t=82
Bottom-right: t=93
New path: t=81

\[ t = 10 \times x \]

\[ x = 1 \]
\[ t = 11 \]

\[ t = 50 + x \]

\[ x = 2 \]
\[ t = 52 \]

\[ t = 50 + x \]

\[ x = 3 \]
\[ t = 53 \]

\[ t = 10 \times x \]

\[ x = 4 \]
\[ t = 40 \]

6000 veh/h
A simple example

\[ x : 10^3 \text{ veh/h} \]
\[ t : \text{time} \]

**1000 veh change**
**Bottom-right \( \rightarrow \) new path**

Left-top: \( t = 92 \)
Bottom-right: \( t = 92 \)
New path: \( t = 92 \)

**Equilibrium**

\[ t = 10 + x \]
\[ x = 2 \]
\[ t = 12 \]
A simple example

- A new infrastructure is built
- Before, travel time = 83 minutes
- After, travel time = 92 minutes

Increasing the physical capacity of the network does not necessarily increase the mobility

- Braess’ paradox
Polluters pay principle

- Concept of marginal travel time
  \[ t = 50 + x \quad \text{Marginal} \quad t = 1 \]
  \[ t = 10 + x \quad \text{Marginal} \quad t = 1 \]
  \[ t = 10 \times \quad \text{Marginal} \quad t = 10 \]
- Drivers are tolled proportionally to the nuisance they produce
- 1 min marginal travel time = 1€
- **Assumption #2**: drivers prefer the cheapest route
Back to the simple example

\[
x : 10^3 \text{ veh/h}
\]
\[
t : \text{time}
\]

Left-top: 11€
Bottom-right: 11€
New path: 21€

Equilibrium
Behavioral assumption?

- Do people minimize time?
- Do people minimize cost?
- Each assumption gives different results
- Behavior is more complex...
Time is money

- Path 1: 11€ - 83 minutes
- Path 2: 11€ - 83 minutes
- Path 3: 21€ - 70 minutes

- Would you be willing to pay 10€ to save 13 minutes?
- Assumption #3: drivers consider both time and cost
- But how do we identify the best path then?
Value of time

- We can measure the willingness to pay for travel time savings


<table>
<thead>
<tr>
<th>WTP at sample mean</th>
<th>Business</th>
<th>Commuting</th>
<th>Leisure</th>
<th>Shopping</th>
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</thead>
<tbody>
<tr>
<td>PT travel time (CHF/hour)</td>
<td>49.57</td>
<td>27.81</td>
<td>21.84</td>
<td>17.73</td>
</tr>
<tr>
<td>Car travel time (CHF/hour)</td>
<td>50.23</td>
<td>30.64</td>
<td>29.2</td>
<td>24.32</td>
</tr>
<tr>
<td>Headway red. (CHF/hour)</td>
<td>14.88</td>
<td>11.18</td>
<td>13.38</td>
<td>8.48</td>
</tr>
<tr>
<td>Interchange red. (CHF/change)</td>
<td>7.85</td>
<td>4.89</td>
<td>7.32</td>
<td>3.52</td>
</tr>
</tbody>
</table>
Value of time

- Assume it is 15€/h, that is about 0.25€/min
- We can convert everything into cost or time
- Path 1&2: 83 min = 20.75€ + 11€ = 31.75€
- Path 3: 70 min = 17.50€ + 21€ = 38.50€
More behavioral aspects

- Value of time varies with
  - Type of choice (mode or route)
  - Trip purpose
  - Income
  - Distance traveled
  - And maybe more...

- Moreover, there’s more than time and cost explaining route choice
- Need for more advanced behavioral models
Examples

- Long distance route choice in Switzerland
  - Travel time
  - Type of road (cantonal, national, freeway)

- Urban route choice in Sweden
  - Travel time
  - Number of left turns
  - Number of speed bumps
  - Number of intersections
Behavior is complex, so are the models

\[ P(i|C_n) = \frac{e^{V_{in} + \ln q(C_n|i)}}{\sum_{j \in C_n} e^{V_{jn} + \ln q(C_n|j)}} \]

\[ q(C_n|i) = q(\tilde{C}_n|i) = \frac{R!}{(k_{in} - 1)!} \prod_{j \in C_n} k_{jn}! \prod_{j \in C_n, j \neq i} q(j)^{k_{jn}} q(i)^{k_{in} - 1} \]

\[ P(i|C_n) = \frac{e^{V_{in} + \ln \left( \frac{k_{in}}{q(i)} \right)}}{\sum_{j \in C_n} e^{V_{jn} + \ln \left( \frac{k_{jn}}{q(j)} \right)}} \]
The human dimension of transport

- Huge topic...
- In this lecture:
  - Focus on travel demand
  - Focus on travel choices
  - Focus on route choice
- But there is much more in our research activities

transp-or.epfl.ch
Pedestrian models

Pedestrian simulation

Multi-camera: mobile and fixed

A. Alahi, M. Kunt
Image analysis: facial expressions

- Signal Processing Institute, EPFL

J-Ph. Thiran, J. Cruz, Th. Robin, M. Sorci, G. Antonini
Transport Planning

- Robert-Grandpierre et Rapp SA
- Service de la mobilité du canton de Vaud
- Transports Lausannois

J.-P. Leyvraz, Th. Robin
Route Choice

- ASTRA
- IVT- ETHZ
- USI-Lugano

E. Frejinger, J. Stojanovic
Airline Scheduling

- CTI: The Innovation Promotion Agency
- APM Technologies, Geneva
Container terminals

- Port of Antwerp, Belgium
- Port of Gioia Tauro, Italy
- Port of Beirut, Lebanon
Land use and transportation

- Stratec, SA, Belgium
- University of Washington, Seattle
Congestion models

- Swiss National Science Foundation
- Hôpitaux Universitaires de Genève
Thank you!

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