Factors Explaining the Use of Cargo Bikes and Cars in Urban Logistics: Results from a Stated Preference Experiment in Germany

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- Motivation
- Project background: cargo bike (CB) trial
- Stated preference (SP) experiment design
- Model results
- Conclusions
Just a “boring“ German street scene…?

How can we shift more trips to cargo bikes?

Vehicle type choice for freight and service trips

Café / bar (possibly destination of service trip)
Parcel delivery van
Double-parked heavy truck
Parked cars
Vehicle passing
Double-parked car used for a service trip

Note: Background picture removed due to copyright
Research question:
Which factors explain the use of cargo bikes (CB) and cars in urban logistics?

Research context and method:
- Organizations willing to change from car (or van) use to CB
- SP choice experiment at the end of a CB trial phase
- Additional RP data
- Mixed logit to model vehicle type choice
Project background: Germany-wide CB trial “Taking the load off cities” (German title “Ich entlaste Städte”)

Large-scale CB trial...
- 152 vehicles
- 2 years of testing in total
- 3 months for each participant

...for a diverse target group...
- Companies of all industries
- Public institutions
- NGOs, initiatives
- Freelancers, self-employed

... with similarities
- All are willing to downshift
- All gained operational CB experience
Some examples of the CB trial participants

Brewery
Beer deliveries to local supermarkets

Toy repair service
Transport of toys

Beekeepers
Transport of beehives

Movie production
Transport of equipment to film location

Church community
Helping priests for on-site visits

Real estate firm
Trips to viewing appointments

Electrical engineering
Customer support trips

Caramel factory
Delivery of sweets
CB trial fleet: 5 main types of construction, 23 different models, 152 vehicles

- Pizza delivery bike
- Tricycle, front load
- Heavy load tricycle
- Long John bike
- "Specialist" CB
- Longtail bike
### Sample descriptive statistics: Vehicle use

<table>
<thead>
<tr>
<th>No. of wheels</th>
<th>Construction type</th>
<th>Typical model</th>
<th>No. of models</th>
<th>No. of participants in sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Pizza delivery bike</td>
<td><img src="image" alt="Pizza delivery bike" /></td>
<td>1</td>
<td>26</td>
</tr>
<tr>
<td>2</td>
<td>Long John bike</td>
<td><img src="image" alt="Long John bike" /></td>
<td>10</td>
<td>206</td>
</tr>
<tr>
<td>3</td>
<td>Longtail bike</td>
<td><img src="image" alt="Longtail bike" /></td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>Tricycle, front load</td>
<td><img src="image" alt="Tricycle, front load" /></td>
<td>6</td>
<td>84</td>
</tr>
<tr>
<td>3</td>
<td>Heavy-load tricycle</td>
<td><img src="image" alt="Heavy-load tricycle" /></td>
<td>4</td>
<td>14</td>
</tr>
</tbody>
</table>

**Distance parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Data basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean daily mileage</td>
<td>12.1 km / 7.5 mi</td>
<td>5,002 GPS-tracked days</td>
</tr>
<tr>
<td>Mean single trip distance</td>
<td>5.1 km / 3.2 mi</td>
<td>11,736 GPS-tracked trips</td>
</tr>
</tbody>
</table>

**Main operational purpose**

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Share of CB trial participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery of goods</td>
<td>21%</td>
</tr>
<tr>
<td>Pick-up / procurement of goods</td>
<td>13%</td>
</tr>
<tr>
<td>Provision of services</td>
<td>38%</td>
</tr>
<tr>
<td>Other business-related errands</td>
<td>25%</td>
</tr>
<tr>
<td>Private errands</td>
<td>3%</td>
</tr>
</tbody>
</table>

**Sum=339** (sample size)
Study design: Overview

Baseline survey (before trial phase) ➔ Cargo bike trial (3 months) ➔ SP survey (at the end of trial phase)

Additional variables ➔ Mixed logit model ➔ SP experiment variables

Baseline survey (before trial phase)

Cargo bike trial (3 months)

SP survey (at the end of trial phase)

Additional variables

Mixed logit model

SP experiment variables

CB

CAR
Study design: Example of a SP choice experiment

SP survey question: *Which vehicle would you choose for a trip under the following conditions?*

**INDEPENDENT ATTRIBUTES**
- TRIP DISTANCE (ROUNDTRIP) 5 km (3.1 mi)
- TEMPERATURE 18 °C (64 °F)
- PRECIPITATION YES

**ALTERNATIVE-SPECIFIC ATTRIBUTES**
- PARKING At point of destination
- INFRASTRUCTURE Safe bike path
- TRAVEL TIME 13 min
- TOTAL COST OF TRIP € 5
- RISK OF DAMAGING GOODS 15 %
- RISK OF DELAY 15 %

**CARGO BIKE**
- Parking available
- Street
- 18 min
- 0 %
- 0 %

**CAR**
- At point of destination
- Safe bike path
- 13 min
- € 5
- 15 %
- 15 %

**TRIP WOULD NOT BE CARRIED OUT UNDER THESE CIRCUMSTANCES**
**Study design: Attributes of SP experiments**

### Independent Attributes
- **Temperature**: -3 °C (27 °F) | 5 °C (41 °F) | 18 °C (64 °F)
- **Precipitation**: Yes | No

### Alternative-Specific Attributes

<table>
<thead>
<tr>
<th>CARGO BIKE</th>
<th>CAR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parking</strong></td>
<td>At point of destination</td>
</tr>
<tr>
<td><strong>Infrastructure</strong></td>
<td>Safe bike path</td>
</tr>
<tr>
<td><strong>Travel Time</strong></td>
<td>13</td>
</tr>
<tr>
<td><strong>Total Cost of Trip</strong></td>
<td>€ 3.5</td>
</tr>
<tr>
<td><strong>Risk of Damaging Goods</strong></td>
<td>0 %</td>
</tr>
<tr>
<td><strong>Risk of Delay</strong></td>
<td>0 %</td>
</tr>
</tbody>
</table>

**TRIP WOULD NOT BE CARRIED OUT UNDER THESE CIRCUMSTANCES**
Results overview: Actual choice of alternatives

Sample size: 3,051 choices by 339 respondents

- **CARGO BIKE**: n=1,815 (59%)
- **CAR**: n=1,088 (36%)
- **NON-CHOICE**: n=148 (5%)
Results overview: Factors explaining the use of cargo bikes and cars

**SP EXPERIMENT VARIABLES**
- TEMPERATURE ✓
- PRECIPITATION ✓
- PARKING ✓
- ROAD INFRASTRUCTURE ✓
- TRAVEL TIME ✓
- TOTAL COST OF TRIP ✓
- RISK OF DAMAGING GOODS ✓
- RISK OF DELAY ✗

**ADDITIONAL VARIABLES**

**ORGANIZATIONAL FACTORS**
- Main operational purpose ✓
- Change in fleet management during CB trial ✓
- Suitability of CB for transport tasks ✓
- Type of organization ✗
- Number of employees ✗
- Fleet configuration prior to CB trial ✗
- Time-critical transports ✗

**INDIVIDUAL FACTORS**
- Operative use of CB by respondent during trial ✓
- Age ✗
- Sex ✗

**CONTEXTUAL FACTORS**
- Population density at trial site ✗
- CB trial was conducted in winter ✗

✓ significant  ✗ non-significant
Results of a Mixed Logit Model: SP experiment variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Base</th>
<th>Choice Ref.</th>
<th>Est. Value</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEMPERATURE</td>
<td>5 °C (41 °F)</td>
<td>-3 °C (27 °F)</td>
<td>CAR</td>
<td>-0.39</td>
<td>-2.76</td>
</tr>
<tr>
<td></td>
<td>18 °C (64 °F)</td>
<td>-3 °C (27 °F)</td>
<td>NC</td>
<td>-1.14</td>
<td>-3.84</td>
</tr>
<tr>
<td>PRECIPITATION</td>
<td>Yes</td>
<td>No</td>
<td>CAR</td>
<td>2.58</td>
<td>20.31</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>NC</td>
<td>3.06</td>
<td>11.64</td>
</tr>
<tr>
<td>PARKING</td>
<td>No stopping zone</td>
<td>Parking available</td>
<td>CAR</td>
<td>-0.52</td>
<td>-4.69</td>
</tr>
<tr>
<td>ROAD INFRASTRUCTURE</td>
<td>Safe bike path</td>
<td>Road with mixed traffic</td>
<td>CB</td>
<td>0.34</td>
<td>3.39</td>
</tr>
<tr>
<td>TRAVEL TIME</td>
<td></td>
<td></td>
<td>CAR</td>
<td>-0.01</td>
<td>-2.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CB</td>
<td>-0.06</td>
<td>-16.53</td>
</tr>
<tr>
<td>TOTAL COST OF TRIP</td>
<td></td>
<td></td>
<td>GEN</td>
<td>-0.04</td>
<td>-5.83</td>
</tr>
<tr>
<td>RISK OF DAMAGING GOODS</td>
<td></td>
<td></td>
<td>GEN</td>
<td>-0.02</td>
<td>-4.24</td>
</tr>
</tbody>
</table>

n=3,051 SP experiments
Log-Likelihood: -1838.1

Moderate temperatures increase the intention to use CB…
… but rain is among the strongest factors to avoid cycling.
Lack of parking prevents car use.
Good bike infrastructure has a noticeable effect.
Longer travel times reduce willingness to use CB to a greater extent than for cars.
CB were rather chosen for the provision of services or other business-related errands than for goods delivery.

Positive effects during trial phase push decisions towards CB.

Individual experience of vehicle use increases CB choice.

Sigmas (normally distributed) take account for the panel effect.

Model results: Additional variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Base</th>
<th>Choice Ref.</th>
<th>Est. value</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAIN OPERATIONAL PURPOSE</td>
<td>Delivery of goods</td>
<td>All other purposes</td>
<td>CAR</td>
<td>0.47</td>
<td>2.53</td>
</tr>
<tr>
<td>CHANGE IN FLEET MGMT DURING CB TRIAL</td>
<td>Positive change</td>
<td>No or negative change</td>
<td>CAR</td>
<td>-0.48</td>
<td>-2.88</td>
</tr>
<tr>
<td>SUITABILITY OF CB FOR TRANSPORT TASKS</td>
<td>High suitability</td>
<td>Low suitability</td>
<td>CAR</td>
<td>-0.93</td>
<td>-5.80</td>
</tr>
<tr>
<td>OPERATIVE USE OF CB BY RESPONDENT DURING TRIAL</td>
<td>Respondent is only CB user</td>
<td>Respondents and others, only others are users</td>
<td>CAR</td>
<td>-0.50</td>
<td>-3.29</td>
</tr>
<tr>
<td>ALTERNATIVE-SPECIFIC CONSTANTS</td>
<td></td>
<td></td>
<td>CAR</td>
<td>-1.92</td>
<td>-8.49</td>
</tr>
<tr>
<td>NC</td>
<td></td>
<td></td>
<td>NC</td>
<td>-7.99</td>
<td>-16.45</td>
</tr>
<tr>
<td>CB</td>
<td></td>
<td></td>
<td>CB</td>
<td>-0.04</td>
<td>-0.15</td>
</tr>
<tr>
<td>SIGMA</td>
<td></td>
<td></td>
<td>CAR</td>
<td>1.00</td>
<td>12.11</td>
</tr>
<tr>
<td>NC</td>
<td></td>
<td></td>
<td>NC</td>
<td>-2.30</td>
<td>-8.42</td>
</tr>
</tbody>
</table>

n=3,051 SP experiments
Log-Likelihood: -1838.1
Conclusions and outlook

- Contribution reveals factors leading to vehicle type choice in an unusual segment of urban logistics with...
  - smaller vehicles involved,
  - short trip distances,
  - service trips and freight trips of non-logisticians.
- Findings are (rather) valid for organizations that are already willing to downshift.
- Service providers might be a better target group for CB deployment than delivery companies.
- Good bicycle infrastructure and reduction of car parking show substantial effects.
- Trial programs can remove reservations and obstacles.
- Rain is much more deterrent than cold temperatures.

One out of the 23 tested CB models was equipped with rain protection.
Thank you! Questions?

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