Carsharing: Why to model carsharing demand and how

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Outline

1. Introduction: What’s going on in the carsharing world?
2. Why to model carsharing demand?
3. Modeling carsharing with MATSim
4. Summary and future work
1. Introduction: What’s going on in the carsharing world?
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Worldwide growth of carsharing

Carsharing in terms of members / vehicles is growing fast

Source: Shaheen and Cohen, 2012
Actors

- The actors involved are increasingly large
  - Car manufacturers → Daimler, BMW, Pegeout
  - Traditional car rental companies → Avis, Sixth
  - Public transport operators → DB
Competition

• The level of competition on the market is increasing

  • At the start of modern carsharing operations (90’s Switzerland and Germany) and until recently, operators mostly were “local monopolists”

  • Now many cities boast several carsharing operators
The world of shared mobility is **evolving fast** and **new services** are coming to the market to **challenge/complement** the **old ones**

- Round trip-based carsharing (Mobility)
- One-way (station based) carsharing (Autolib)
- Free-floating carsharing (Car2go, DriveNow)
- Peer-to-peer carsharing (RelayRides)

- Bike-sharing
- Carpooling
- Dynamic ride sharing
- Slugging
- ...
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Why do we need to model carsharing demand?

Models are used to get insight on the behavior of a transportation system under given circumstances

but

Is carsharing relevant?
Because...

- Still small but conceptually "mainstream" ("Shared economy")
- Fits well with some **societal developments** ("Peak car")
- Is often mentioned when it comes to make transport more **sustainable** (but the mechanisms aren’t clear)
...and also because...

- The **actors** involved are increasingly **large** → Able to have a “big bang” approach, implies **large investments**

- The level of **competition** on the market is increasing → **Higher investment risk**

- The world of shared mobility is **evolving fast** → Incertitude about **integration/competition** among different modes/systems
Research Goal

• Build a **predictive** and **policy sensitive model** that can be used by **practitioners (operators)** and **policy makers**
Methodology: Observations

- Inherent **limitations** of **traditional models** representing carsharing – the importance of CS **availability** at **precise points** in **time** and **space** is not fitting with vehicles per hour flows.

- **Travel** is the result of the **individual need** performing out-of-home **activities** at different locations – this matters for carsharing even more than for other modes! (according to the length / location of the activities)
1. Introduction: What’s going on in the carsharing world?
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3. **Modeling carsharing with MATSim**
4. Summary and future work
MATSim

It sketches **individuals’ daily life** using the agent paradigm.

Agents have **personal attributes** (age, gender, employment, etc.) which influence their behavior.

Agents **autonomously** try to **carry out a daily plan** being able to **modify** some dimensions of their **travel** (time, mode, route, activity location)

High **temporal** and **spatial resolution**

**MATSim** = Multi-agent transport simulation ([www.matsim.org](http://www.matsim.org))
Carsharing model in MATSim – Current status

• Traditional carsharing + Free-floating (by senozon)

  • Agents always walk from the starting facility to the closest car
  
  • Time and distance dependent fare
  
  • Stations are located at the actual carsharing locations in the modeled area
  
  • Carsharing is available only to members
  
  • Actual vehicle availability is accounted for
Test Case 1 - Berlin

Part of a German project called “Berlin elektroMobil” → Berlin, Germany as a test case

Goals:

• Understand the behavior of the whole transportation system under different carsharing scenarios

• Finding strategies to extend the carsharing supply in Berlin and get hints on how to combine free-floating (FF) and station-based (SB) carsharing
Scenarios

- Scenario I: SBCS (Basis, station based only, reflecting actual supply)

- Scenario II: Expanded SBCS (Station based only, additional stations and members)

- Scenario III: Scenario II + Free-floating

<table>
<thead>
<tr>
<th></th>
<th>Scenario I</th>
<th>Scenario II</th>
<th>Scenario III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>4’422‘012</td>
<td>4’506‘058</td>
<td>4’506‘058</td>
</tr>
<tr>
<td># Members CS SB &amp; FF</td>
<td>20‘000</td>
<td>38‘000</td>
<td>38‘000</td>
</tr>
<tr>
<td># Members CSFF</td>
<td>-</td>
<td>-</td>
<td>194‘000</td>
</tr>
<tr>
<td># CS Stations</td>
<td>82</td>
<td>152</td>
<td>152</td>
</tr>
<tr>
<td># Vehicles (Station based)</td>
<td>175</td>
<td>329</td>
<td>329</td>
</tr>
<tr>
<td># Vehicles Free-floating</td>
<td>-</td>
<td>-</td>
<td>2‘500</td>
</tr>
<tr>
<td># Members traveling (any mode)</td>
<td>16‘489</td>
<td>31‘358</td>
<td>191‘819</td>
</tr>
</tbody>
</table>
**Statistics overview**

<table>
<thead>
<tr>
<th></th>
<th>CS SB (Scenario I)</th>
<th>CS SB (Scenario II)</th>
<th>CS SB (Scenario III)</th>
<th>CS FF (Scenario III)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong># Trips</strong></td>
<td>496</td>
<td>1'298</td>
<td>1'379</td>
<td>10'708</td>
</tr>
<tr>
<td><strong>Avg. Trip Duration [min]</strong></td>
<td>22.9</td>
<td>23.5</td>
<td>27.5</td>
<td>20.1</td>
</tr>
<tr>
<td><strong>Avg. OD-Distance [km]</strong></td>
<td>5.8</td>
<td>5.3</td>
<td>5.3</td>
<td>5.7</td>
</tr>
<tr>
<td><strong>Total travel time [Days]</strong></td>
<td>7.9</td>
<td>21.2</td>
<td>26.5</td>
<td>149.8</td>
</tr>
<tr>
<td><strong>Total distance [km]</strong></td>
<td>2'900</td>
<td>6'900</td>
<td>7'300</td>
<td>60'600</td>
</tr>
</tbody>
</table>

- **Over-proportional increase** of SB rentals (increasing stations / cars)
- **Trips** (distance and travel time) essentially **unchanged**
- Adding FFCS (2’500 cars) → ~ 10’000 additional trips and SBCS grows
- **SB** (S III) **shorter** trips (distance), **FF** slightly **longer but faster** trips.
**Purpose**

**FF CS** has **more Work** and **less Leisure** travel compared to **SB CS**
Modal substitution

Mode substituted by free-floating carsharing

- **Car travel** is the mode which is *reduced the most* (> 30%) of the free-floating trips were car trips before its introduction.

- Overall **car travel** (VMT) *grows* with FF compared to SB only → **modal substitution** patterns for free-floating carsharing might be problematic.

- Relatively **few agents changed from SB to FF carsharing**
Conclusions

• **Untapped potential for SBCS** in Berlin – **Over-proportional growth** of SB doubling # carsharing cars

• **SB** carsharing is **used more intensively** after **FF** carsharing is introduced

• Some **differences** in the **use** of the two CS modes (**purpose**, **time**, **distance**)

• **Substitution patterns** are a possible **concern** for **FF**

• Apparently **FF** and **SB** are rather **complementary**
Test Case 2 - Zürich

Goals:

• Understand the behavior of the whole carsharing system under different (carsharing) pricing scenarios

• Get hints on the interactions between traditional station based carsharing and free-floating carsharing under such scenarios
## Scenarios

<table>
<thead>
<tr>
<th></th>
<th>Scenario I</th>
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<th>Scenario III</th>
<th>Scenario IV</th>
<th>Scenario V</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SB Time Fee</strong></td>
<td>4.52 SFr./h</td>
<td>4.52 SFr./h</td>
<td>4.52 SFr./h</td>
<td>4.52 SFr./h</td>
<td>4.52 SFr./h</td>
</tr>
<tr>
<td><strong>SB Distance Fee</strong></td>
<td>0.18 SFr./Km</td>
<td>0.18 SFr./Km</td>
<td>0.18 SFr./Km</td>
<td>0.18 SFr./Km</td>
<td>0.18 SFr./Km</td>
</tr>
<tr>
<td><strong>FF Time Fee</strong></td>
<td>-</td>
<td>0.237 SFr./min</td>
<td>0.118 SFr./min</td>
<td>0.118 SFr/min (10-16) 0.237 SFr/min (rest of day)</td>
<td>0.237 SFr./min</td>
</tr>
<tr>
<td><strong>FF Distance Fee</strong></td>
<td>-</td>
<td>0.29 SFr./Km</td>
<td>0.29 SFr./Km</td>
<td>0.29 SFr./Km</td>
<td>0.29 SFr./Km</td>
</tr>
<tr>
<td><strong>FF Free Distance</strong></td>
<td>-</td>
<td>20 Km</td>
<td>20 Km</td>
<td>20 Km</td>
<td>0 Km</td>
</tr>
</tbody>
</table>
Vehicles in Motion

Scenario I

Scenario II

Scenario III

Scenario IV

Scenario V
Modal substitution

Modes substituted by free-floating carsharing in scenarios II to V as compared to scenario I. The secondary axis shows the number of free-floating rentals for the scenario.
Rentals spatial patterns
Purpose of the rental

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Scenario I</th>
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<th>Scenario III</th>
<th>Scenario IV</th>
<th>Scenario V</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT CS</td>
<td>1h23’9”</td>
<td>1h39’7”</td>
<td>1h44’7”</td>
<td>1h24’28”</td>
<td>1h26’29”</td>
</tr>
<tr>
<td>FF CS</td>
<td>-</td>
<td>2h45’58”</td>
<td>2h16’56”</td>
<td>2h34’38”</td>
<td>2h12’45”</td>
</tr>
<tr>
<td>Car</td>
<td>3h58’2”</td>
<td>3h58’14”</td>
<td>3h58’</td>
<td>3h57’53”</td>
<td>3h57’47”</td>
</tr>
</tbody>
</table>
Conclusions

- The impact of different pricing schemes is not limited to increasing or reducing the aggregate level of usage.

- Pricing strategy structurally affects the interactions between the two carsharing types.

- Complex interactions between spatiotemporal availability of carsharing vehicles and users are observed.

- The realism of some aspects (i.e. purpose, modal substitution) is still unclear.
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Summary

• **Carsharing** is growing fast and is becoming «mainstream»

• Instruments for the **modeling of carsharing** are becoming necessary

• **Traditional models** are **not** well suited to model carsharing

• **MATSim** is already able to **simulate carsharing** and to evaluate complex scenarios...

  ...but there are still **many limitations**
Ongoing work

• Improving the existing membership model

• Testing our implementations of free-floating and one-way carsharing
Future work

- **Further validation** of the existing results with *empirical data*
- Applying the tool for analysis on *new scenarios*, possibly relying on *new empirical data*
- Improve the simulation with *better behavioral models*
- New case studies where different *shared mobility options* (Autonomous Vehicles, Ride Sharing) are combined
Thank you for your attention!

www.matsim.org