Concepts and impacts of new urban shared mobility alternatives: An agent-based simulation model for the city of Lisbon, Portugal

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International Transport Forum
The big challenges: Emissions, Air Quality and Congestion

- Emissions (Carbon, pollutants) from urban transport still a significant part of the whole
  - In spite of progress towards cleaner vehicles
  - Considerable lifespan of vehicles limits emission reductions from new technologies
- Across the whole world, heavy congestion in urban areas
  - Building more infrastructure leading to self-saturation everywhere
Sharing

The least used resources in urban mobility (vehicles and in-vehicle space)

Ride-sharing (Shared Taxis)

Very poor capital utilization
Quality Requirements for Public Acceptance

- As the idea is to get most current car trips into shared rides, quality level must be quite high
  - Door-to-door service
  - Great convenience
    - Short waiting time
    - Travel time similar to that of driving your car
    - No concern with parking
    - Very easy transaction (smartphone based)
  - Good comfort on board
  - Price not higher than today
Agent-based simulation for a real city (Lisbon)
real trips on a detailed network model (currently only urban core)
Two configurations with Ride-sharing
(the new paradigm for demand-responsive public transport):

<table>
<thead>
<tr>
<th>2 modes</th>
<th>3 modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>All trips in motorized road modes shift to Shared Taxis, or partly stay in private cars</td>
<td>All trips in motorized road modes served by Shared Taxis and Taxibuses (on-demand buses), or partly stay in private cars</td>
</tr>
</tbody>
</table>

In all configurations, **existing Metro service present**
Private car use tested from 0% to 60% of current users
Quality of Service for Shared Taxis

- **Max. acceptable delays** variable with direct distance of trip
  - a) **Waiting time**
    - from 5 minutes (\(\leq 3\) km), up to 10 minutes (\(\geq 12\) km)
  - b) **Total “lost” time** (wait + detour)
    - from 7 minutes (\(\leq 3\) km), up to 15 minutes (\(\geq 12\) km)

- **Comfort**
  - minivan currently seating 8 rearranged to seat only 6
  - easier and faster entry and exit
Demand responsive Taxibuses

- Fully demand-responsive (Buses to fit your individual requirements, not you to fit their routes and schedules)
- Good service, but not as high quality as shared taxis
  - Booking at least 30 min in advance (regular booking as norm)
  - Boarding and alighting up to 400 m away from door, at points designated in real time
  - Tolerance of 10 min from preferred boarding time
- All trips without transfer
- Minibuses with capacity 8 and 16
- Adjustment of service quality parameters allows different distributions of demand between Shared Taxis and Taxibus
Some key indicators for % private car trips
(except for avg. pax on board, all cases in % relative to current = year 2010):

<table>
<thead>
<tr>
<th>Aggregate Indicators</th>
<th>2 modes</th>
<th>3 modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. Pax on board (Sh.taxis)</td>
<td>2.3 (peak 3.0)</td>
<td>2.0 (peak 2.3)</td>
</tr>
<tr>
<td>Avg. Pax on board (Taxibus)</td>
<td>---</td>
<td>4.1 (c8) / 9.4 (c16) Peak: 5.1 (c8) / 12.1 (c16)</td>
</tr>
<tr>
<td>Fleet size (Sh. taxis + buses)</td>
<td>4.8%</td>
<td>2.8% (cars) Bus*: 573% veh. / 81 % (pl.)</td>
</tr>
<tr>
<td>VKM (weighted) all-day</td>
<td>86%</td>
<td>77%</td>
</tr>
<tr>
<td>VKM (weighted) peak-hour</td>
<td>82%</td>
<td>63%</td>
</tr>
<tr>
<td>CO2 emissions</td>
<td>84%</td>
<td>66%</td>
</tr>
</tbody>
</table>

* - but these will be micro-buses with capacities 8 and 16, not standard urban buses, with capacity 80
In both configurations: 95%+ reduction of parking space needs
Major improvements on key objectives:

- In the 3-mode configuration (Metro, Shared Taxis & Taxibuses), no congestion, even at peak
  - VKM at peak 37% lower than current

- Much lower emissions
  - Short-term due to reduced VKM (34% lower than current)
  - Mid- and long-term even better given faster fleet turnaround (each vehicle travels much more)

- Results for 2-mode configuration also very good on reduction of emissions and congestion
Some Key results for 3-mode Configuration:

- With the parameters in this simulation, modal split is 67% for Shared Taxis and 33% for Taxibus
  - Sometimes (~20% of cases) a client asking for a Taxibus will be upgraded to a Shared Taxi, because it is more efficient on the supply side

- Overall, a much better situation than currently for Public Transport
  - Higher quality:
    - No transfers
    - Much shorter waiting times and access walks
    - Seat always available
In the 3-mode configuration, with

- professional drivers in 8- and 4-hour shifts,
- uniform tariff/pax.km in each mode,
- a margin of 25% above operational costs for other costs and profits,

Tariffs required for cost coverage would be:

- Shared taxi: 31% of current taxis
- Taxibus: 45% of current price using public transport monthly card, or
  29% of current cost of public transport, considering subsidies
  60% of the Shared Taxi price in this system
Break-even tariffs vs. own car costs

- The cost of using shared taxis was compared with the costs (ownership and operation) associated with using your own car.
  - Commuting was supposed to represent 80% of the usage value of your own car.
- 4 types of private car were considered:
  - New, purchase cost 15 k€
  - New, purchase cost 30 k€
  - New, purchase cost 50 k€
  - Second-hand, purchase cost 5 k€
- The graphic shows the daily costs associated with each option for a range of kms/day.
  - For even the low cost (15 k€) new cars, shared taxis cost less for daily distances up to 45 km.
Impacts of retaining some private car trips

- Retaining some private car trips reduces the overall efficiency but facilitates public acceptance and transition into a system mostly based on shared rides
  - Configurations tested for private cars accepted in city 1, 2 or 3 days per week (roughly 20%, 40%, 60% of trips)
  - Key indicators for configuration with 4 modes (Metro, Shared Taxi, Taxibus, Private car) for different percentages of current car trips kept in private cars

<table>
<thead>
<tr>
<th>Aggregate Indicators</th>
<th>0% private cars</th>
<th>20% private cars</th>
<th>40% private cars</th>
<th>60% private cars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active fleet size (Sh. Taxis + priv. cars)</td>
<td>2.8%</td>
<td>2.6% + (20%)</td>
<td>2.4% + (40%)</td>
<td>2.2% + (60%)</td>
</tr>
<tr>
<td>Prices rel. to current (Sh Taxi / Taxibus)</td>
<td>31% / 45%</td>
<td>32% / 45%</td>
<td>33% / 48%</td>
<td>35% / 49%</td>
</tr>
<tr>
<td>VKM (weighted) peak-hour</td>
<td>63%</td>
<td>75%</td>
<td>87%</td>
<td>98%</td>
</tr>
<tr>
<td>CO2 emissions</td>
<td>66%</td>
<td>75%</td>
<td>86%</td>
<td>97%</td>
</tr>
<tr>
<td>% parking space released</td>
<td>97%</td>
<td>77%</td>
<td>58%</td>
<td>38%</td>
</tr>
</tbody>
</table>
Transition Issues:

• Radical change of the paradigms of urban mobility and of public transport
  ➢ Governance, Public transport and taxis must adapt

• Possibly interesting path:
  ➢ Initially give 2-day / week access for private cars (~13% reduction of traffic and emissions), with later reduction to 1-day / week access (12% further reductions)
  ➢ Quality of service and cost advantage of shared rides should help move modal split in the right direction
Policy insights - KPIs:

• Solutions for the key challenges are within reach, with today’s technology
  ➢ Strong reduction of emissions
  ➢ No congestion
  ➢ High quality of service → good acceptance expectable in all segments
  ➢ Lower or Zero subsidy for Public Transport

• Further reduction of VKM expectable from great improvement of walking and cycling conditions made possible from massive release of parking space
  ➢ Part of that space usable also for new developments (e.g. missing public services in some neighbourhoods)

• Accessibility could improve from denser and diversified land-use, higher use of active modes, reduced congestion on road transport
Policy insights: Further value

• Large part of urban deliveries can be performed off-peak by the same Shared Taxi vehicles (if seats are easily collapsible)
  • Part of this fleet also easily adapted for transport of mobility impaired people
• Massive release of underutilised private capital (cars)
• This is a rather complex optimization process, results will vary according to parameters used for the allocation of people to modes and vehicles
Policy insights: Expansion, Transfer

- Results from one city are never fully and directly transferable to another city, but
  - Lisbon has relatively low density, efficiency of sharing increases with city density
  - For each city, calibration of quality parameters allows some space for precise targeting of results

- Next steps:
  - Expansion to cover whole of Lisbon metropolitan area
    - Taxibus services as feeders into railway stations (in suburbs and in city center)
  - Bring together a relatively small group of cities for simulation with their own data
Thank you!
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