Impact analysis of a new metro line in Amsterdam using automated data sources

Transit Data 2019

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Background

- The north-south metro line (NZL) opened on 22nd July 2018 in Amsterdam
- Changes to the whole network
Objective

• To study the impact of the network change on
  – ridership,
  – travel times,
  – reliability
• from a passenger perspective - considering journeys including transfers within and across modes
• distributional analysis
Data sources

- **Smartcard data**
  - Tap-in and tap-out location and times
- **Automatic Vehicle Location (AVL) data**
  - Vehicle number, stop location and time stamps

**Before NZL:**
11th Sept - 15th Oct 2017 (5 weeks)

**After NZL:**
10th Sept - 21st Oct 2018 (6 weeks)

North-South metro line opens (22\textsuperscript{nd} July 2018)
Amsterdam PT Network

- ~850,000 inhabitants
- 5 metro lines
- 15 tram lines
- 44 bus lines
- >700,000 smartcard transactions per day
Data pre-processing

1. Smartcard data
2. AVL data
3. Data Cleaning
4. Data Fusion
5. Destination Inference
6. Transfer Inference
7. Journeys Database

References:
- Trépanier et al. (2007)
- Gordon et al. (2013), Yap et al. (2017)
Travel time using smartcard data

- In-vehicle time
- Waiting time
- Transfer time
- Waiting time
- In-vehicle time

Mode 1

$t_0$, $t_1$, $t_2$, $t_3$, $t_4$, $t_5$

Mode 2
Travel time using smartcard data

- Where first tap-in at station (e.g. Amsterdam Metro)
  - Total travel time ($t_5-t_0$)

- Where first tap-in inside vehicle (e.g. Amsterdam buses & trams)
  - Total travel time minus waiting time at origin ($t_5-t_1$)
Waiting time at origin

- For journeys where first tap-in is inside the vehicle
  - Time passenger arrived at stop is not known
  - Headway of services known (from AVL data)
  - For short headway services – passengers assumed to arrive randomly
  - Continuous random variables generated and sampled over uniform distribution \([0, \text{observed headway}]\) to estimate waiting time for each journey

618 Transit Stops
Transit Stop Clustering

• To make before and after situation comparable
• Increased sample size → only OD pairs with minimum 40 journeys preserved due to privacy regulations
Transit Stop Clustering

- Hierarchical clustering
- Maximum (Euclidean) distance threshold of 700m between transit stops
Transit Stop Clustering

618 Transit Stops

201 Transit Stop Clusters
# Journey Statistics

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Before NZL</th>
<th>After NZL</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Journeys</td>
<td>19,577,474 (5 weeks)</td>
<td>24,569,654 (6 weeks)</td>
<td>+4.0%</td>
</tr>
<tr>
<td>Average journeys per weekday</td>
<td>621,099</td>
<td>645,667</td>
<td>+4.0%</td>
</tr>
<tr>
<td>Total stop cluster pairs per weekday</td>
<td>31,650</td>
<td>31,523</td>
<td>-0.4%</td>
</tr>
</tbody>
</table>
Impact on Mode Shares

*Based on average journeys for a weekday (24 hours)

>50% of journeys after NZL include a metro leg
Travel time savings & loses

*Based on stop cluster pairs with minimum 40 journeys for weekdays (7am to 7pm)
Travel time savings & loses – by origin
Reliability measurement

- **Reliability buffer time (RBT)** (Chan, 2007; Uniman et al, 2010)
  
  Difference between the 95th and 50th percentile travel time experienced by travelers **between a stop-stop pair using a specific route**

  \[
  RBT_{o,d,r} = tt_{95}^{o,d,r} - tt_{50}^{o,d,r}
  \]

  Interpreted as the additional time passengers have to budget for their travel to ensure on-time arrival one out of twenty times.
Impact on reliability

*Based on OD-route pairs with minimum 20 journeys and stop cluster pairs with minimum 40 journeys for weekdays (7am to 7pm)
Impact on number of transfers made

*Based on stop cluster pairs with minimum 40 journeys for weekdays (7am to 7pm)
Impact on number of transfers made
Conclusion

• Application of smart card and AVL data for evaluation of a major infrastructural change
  – Consistent measurement of travel times across modes and routes

• Transit stop clustering enabled before/after comparison at a disaggregate level
  – Overall travel savings, but large differences between OD-pairs
  – Better reliability on average
  – Trade-off between transfers and travel times

• Could be used to refine the demand predictive ex-ante tools
Future Work

• Impact on crowding & transfers
• Equity impact of the network change
• Comparison with more aggregate (zonal) analysis
• Route choice behaviour
Thank you!

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