Unexpected flexibility of public transit usage revealed from mining Israel’s smartcard data

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The state of Israeli transportation system is really challenging

Number of motor vehicles by types, 1986 - 2017

Thousands

0 500 1,000 1,500 2,000 2,500 3,000 3,500

Private Track Motorbyke Other
The state of Israeli transportation system is really challenging

Source: Dr. Nir Sharav, NS Associates, Autonomous Vehicle in Israel Day, October 2018
The state of Israeli transportation system is really challenging

Traffic density is the highest in Europe...


Source: Dr. Nir Sharav, NS Associates, Autonomous Vehicle in Israel Day, October 2018
The state of Israeli transportation system is really challenging

Source: Dr. Nir Sharav, NS Associates, Autonomous Vehicle in Israel Day, October 2018
What can be the future of mobility in Israel?

City of Two-Wheeled Vehicles

City of Autonomous Vehicles

Mobility as a Service (MaaS)

WHAT NEXT?
Israeli Transportation and Mobility Data
GTFS (General Transit Feed Specification)
Data on stops, lines, bus trips and timetable
Updated every day

Israel totals:
*Stops:* 30K
*Bus lines:* 3.5K
*Bus Trips/Day:* 250K
*Timetable:* ~10M records
MOBILE PHONE CDRs, VEHICLES GPS, BOARDING COUNTS
Israeli Smartcard system is “TAP-ON” only

- Like almost everywhere in the world, Israeli bus Smartcard system is TAP-ON. Traveler is registered only when boarding.

- Israeli train Smartcard system is TAP-ON/TAP-OFF.
THE DATASETS – RAV-KAV + GTFS

~4M records of all types per day
4 weeks of Nov-2017 and Nov-2018, no holidays

Boarding record attributes (% of valid records):

- Unique SmartCard_ID – 100%
- ID of Boarding Station (GTFS) - 60%
- Boarding Time (date + time) – 100%
- Bus line ID – 80%
- User profile (Standard, Senior, Pupil, Student, …) – 100%
- Agreement (basic fare, daily/weekly/monthly pass) – 100%
- Full records ~ 50%
Trips and travelers (Nov-2017 and Nov-2018)

Travelers with more than 12 boardings per one of the days excluded (0.3% travelers, 1.5% of boardings)

**Unexpected outcome #1** – 27% of travelers board once a day

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**WEEKLY STATISTICS**

- **14.5M** (2017) – **15.5M** (2018) smartcard boardings
- **2.9M** (2017) – **2.4M** (2018) paper ticket boardings
- **1.7M** (2017) – **1.9M** (2018) unique travelers

Average boardings per traveler (workday) **2.7**

Average PT use - **3 days per week**

**TRANSITDATA 2019, Paris**
Daily boarding dynamics by hours
working days and the weekend

TRANSITDATA 2019, Paris
Number of travel days per week

- 26.5% use PT one or two days per week
- 17.5% use PT three days per week
- 16.6% use PT four days per week
- 12.5% use PT five days per week
- 13.2% use PT six days per week
- 12.1% use PT seven days per week
- 1.6% use PT eight or more days per week

14-20.10 – 1,709,401 unique users

Unexpected outcome #2: 45% of travelers use PT one or two days per week
Many travelers use PT only few times a month

**Unexpected outcome #3:**

50th percentile of the number of boardings during 20 working days

- **2017 – 15**
- **2018 – 13**

33% percentile

- **2017 – 7**
- **2018 – 6**
Analysis by users’ profiles
Fraction of travelers by profiles

MP's – 500 trips/month
Once-a-day riders – fractions by profiles

Population average – 27%

Once-a-day riders among all profile’s travelers

Population average – 27%
Weekly PT-use pattern, by profiles
Boarding time by profiles

TRANSITDATA 2019, Paris
Monthly use of PT is similar for most of the profiles, besides pupils (“below 18”), who travel less than the rest.
Type of agreement really matters

Free pass (25%) Annual/Monthly/Weekly/Daily vs Basic fare (75%)

<table>
<thead>
<tr>
<th>Boardings/day</th>
<th>Total share</th>
<th>Free pass</th>
<th>Basic fare</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27%</td>
<td>11%</td>
<td>33%</td>
</tr>
<tr>
<td>2</td>
<td>35%</td>
<td>34%</td>
<td>36%</td>
</tr>
<tr>
<td>3 – 4</td>
<td>27%</td>
<td>35%</td>
<td>23%</td>
</tr>
<tr>
<td>5 – 6</td>
<td>8%</td>
<td>14%</td>
<td>6%</td>
</tr>
<tr>
<td>7 – 12</td>
<td>3%</td>
<td>6%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Days/week

- 1 day: 27.34%
- 2 days: 17.37%
- 3 days: 16.43%
- 4 days: 12.31%
- 5 days: 11.74%
- 6 days: 12.89%
- 7 days: 12.89%
- 1.92% for other days
- 4.49% for 4 days
- 10.24% for 5 days
- 13.77% for 6 days
- 21.82% for 7 days
- 20.78% for 2 days
- 8.97% for 3 days
- 8.28% for 1 day
- 9.16% for other days

Boardings/day Total share Free pass Basic fare
1 27% 11% 33%
2 35% 34% 36%
3 – 4 27% 35% 23%
5 – 6 8% 14% 6%
7 – 12 3% 6% 2%
Type of agreement really matters
Free pass (25%) Annual/Monthly/Weekly/Daily vs Basic fare (75%)

Free Pass, up to 99th percentile

Basic Fare, up to 99th percentile
Spatial patterns
Regular users of PT have several *activity centers*
Typical number of activity centers is 4 – 6 (75% of boardings), and they represent ~1/3 of all stops used during a month. The rest 2/3 of stops are used for less than 25% boardings.
Many-time-a-day travelers
Alighting stop are recognized according to Trépanier et al (2007)*

Last line of a day can take home ~80% of PT-users that start their day with a PT trip

"Stop-Line distance" view overestimates PT commuting...

More than 20% of many-time-per-day riders do not get home with the PT (compare to 27% of once-a-day riders)
The nearest stop of the line of the last trip is close to the stop used for boarding in the morning.
Commuters are not that many

Proxy of Ma et al, 2017: 
Commuters repeatedly start they daily travel activities not far from their home, and repeatedly board last daily trip near the same job
Broader than home-work-home travelers, e.g. students

Two major clusters of PT users by the frequency of use/time of boarding:

**Commuters (~25%) and Free Travelers (75%)**

Commuters use PT 3+ days per week
Once-a-day riders
Once-a-day riders 27%

2/3 of once-a-day riders board twice or more some other day of the week. 1/3 of them are all-week once-a-day riders.
High share of the Once-a-Day riders: fact or artifact?

<table>
<thead>
<tr>
<th>Artifact</th>
<th>Counter-argument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traveler rides and then walks back</td>
<td><strong>Verified now:</strong> inter-urban vs intra-urban lines, different expectations from different profiles</td>
</tr>
<tr>
<td>Traveler stays at the destination overnight</td>
<td><strong>Verified now:</strong> times of traveler’s boardings different days, can trip of the next day be a trip back, etc. Indirect estimates result in max 10-15%.</td>
</tr>
<tr>
<td>More than one smartcard per traveler</td>
<td><strong>Unlikely.</strong> To avoid thefts, old smartcard must be cancelled in order to get a new one</td>
</tr>
<tr>
<td>Traveler uses both smartcard and paper ticket</td>
<td><strong>Unlikely.</strong> Smartcard is valid everywhere and the basic fare of the smartcard is always the same or lower than the price of the paper ticket</td>
</tr>
<tr>
<td>High rate of fare evasion, encouraged by operators</td>
<td><strong>Verified now.</strong> Fees + subsidy $\approx$ constant. Operators have similar conditions of subsidizing, statistics do not vary much by operators</td>
</tr>
</tbody>
</table>

If a “fact,” then many travelers use more than one mode during a day...
25% Rules of thumb

- At least 25% of bus travelers combine between the PT and non-PT modes to reach their daily activities.
- At least 25% of travelers use PT very infrequently – not more than one day a week or not more than 4-5 trips per month.
- Only 25% of travelers constantly repeat the same morning trip to work and evening trip home.

The share of “non-routine” trips, when travelers decide on mode anew, is much higher than we have expected.

Travelers would accept, for these trips, any mode that provides better service, they are waiting for MaaS!
Will MaaS resolve our problems?
THANK YOU!

https://www.geosimlab.org/

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