

The unexpected flexibility of public transit usage revealed from mining Israel's smartcard data

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Extended Abstract

Public Transit (PT) networks usually remain stable for years. Changes in infrastructure based PT (rail-based and some BRT's) are limited to time table variation while potentially flexible bus networks remain steady for long periods of time interrupted by infrequent but intensive updates (“bus reforms”). These phenomena can be considered as an outcome of a rather cumbersome assumption of transport planning that urban inhabitants adopt habitual activities and their travel patterns remain thus stable over time.

In fact, the behavior of residents and businesses in modern cities changes constantly both over space and in time, inducing patterns that are difficult to serve by the existing PT network. This discrepancy can result in a practical bifurcation of travelers’ mode choice. Travelers who have no access to private cars become captives of PT, no matter what the level of the PT service is, while the rest use the car almost exclusively, ignoring the outdated PT-based mobility. This is the essence of the “*PT is for commuters*” hypothesis that suggests that PT travelers are mainly captives and their three major groups have characteristic travel behavior: working commuters (morning and evening peaks), students and pupils (morning peak and noon or afternoon peak) and senior citizens (mostly travel off peak). Smartcard research has largely followed this assumption focusing on origin-destination (OD) matrix identification (Wang et al. 2011) (Gordon et al. 2013) (Alfred Chu & Chapleau 2008), but recently started to reveal high flexibility of PT users (Huang et al, 2018).

Our analysis of the Israeli smartcard data suggests refuting this hypothesis. Several weighty facts bring us to assert that Israeli PT users are quite flexible in their mode choice and, thus, may easily accept new PT modes with higher than the existing Level-of-Service (LOS).

The smartcard system in Israel reached its mature state by September 2017 and this paper discusses boarding records collected over 4 weeks in October and early November 2017. Similar data for 4 weeks of November 2018 served as a control (both periods without holidays) and show very similar phenomena. In 2017, the weekly number of boardings with the smartcard is 14M (15.5M in 2018) including 3M (2.5M in 2018) paper tickets; the number of unique smartcard-users per week is 1.7M (1.9M in 2018). The number of the unique smartcard-users per months is 2.0M in 2017 (2.3 in 2018). The analysis below focuses on the transaction of ticket validation when boarding a PT vehicle – bus (boarding only) or train (also alighting) - for the purpose of traveling. The knowledge on train ticket validation from the alighting stations and bus stops recognized according to the algorithm by (Trépanier et al. 2007) were not used in this paper.

Each record includes: *SmartCard_ID*, *User_Profile*, *Operator* and *BoardingTime* in 100% of records, *Line_ID* in 90% and *Boarding_Stop* in ~60%. About 0.1% of the smartcard users boarded more than 12 times a day (mostly bus/train employees) and were excluded from the analysis.

More than a quarter of smartcard owners board once a day only (Table 1). We assert that this share cannot be explained by possible irregularities of PT users' behavior, as purchasing paper ticket for some of the rides, walking on one of the travel legs, or erroneous work of the device in a bus/train station.

Number of boardings	Share
1	27%
2	35%
3 – 4	27%
5 – 6	8%
7 – 12	3%

The total share of users who use PT 1 or 2 days a week is 44% (Figure 2). this outcome is basically different from the expectation of the "PT is for commuters" hypothesis. The share of users who travel one day a week only is ~27%, very close to the share of once-a-day riders, while the share of users who would comply with the "PT is for commuters" hypothesis and use PT 3 - 5 days is only 41%.

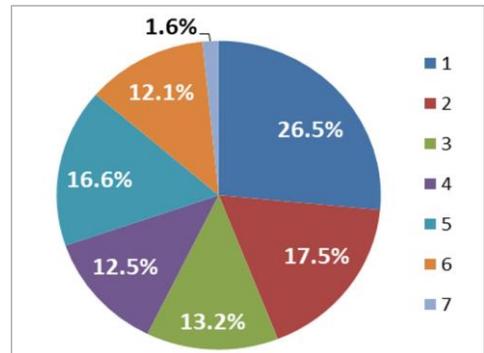
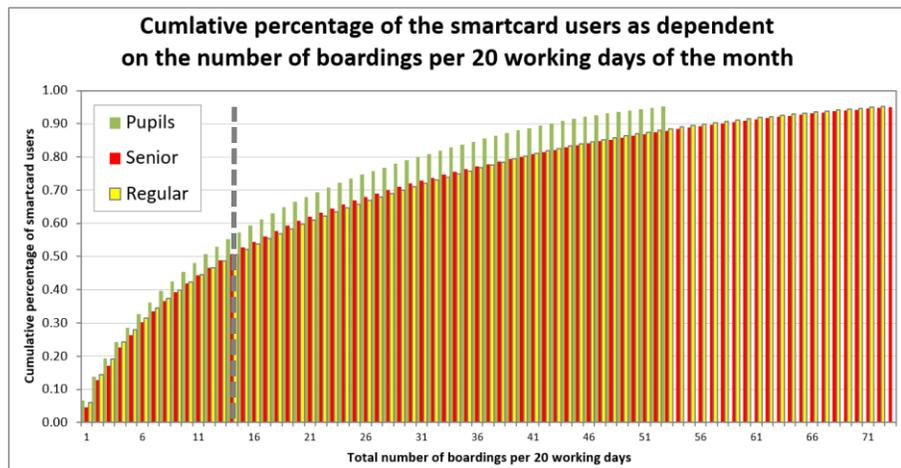


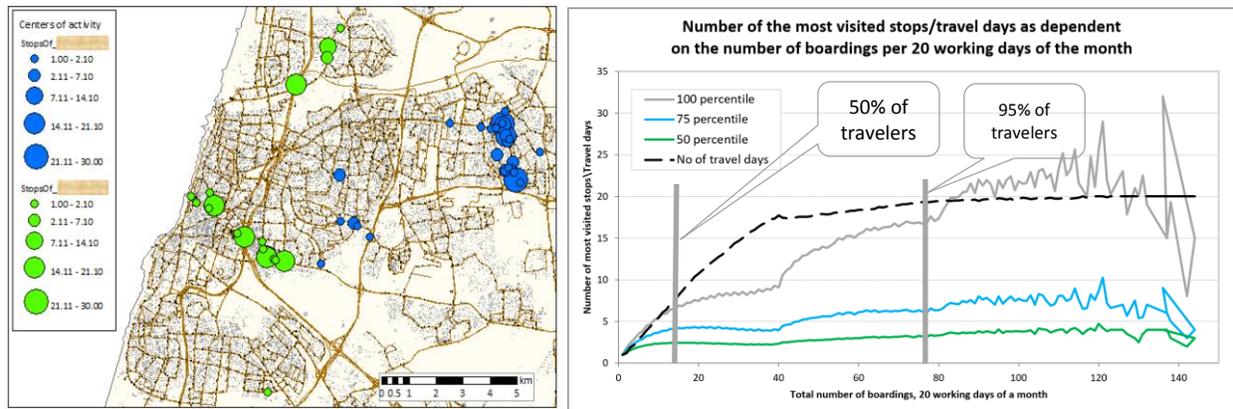
Figure 2 Number of days of weekly PT

Monthly use of PT follows the tendency revealed in the shorter-term analysis: **Half of the PT users board less than 13-15 during 20 working days** (Figure 3). For Regular and Senior user profiles half of all travelers travel less than 15 times a month, while for the Pupils the median is even lower, 12 boardings.

Figure 3. Monthly use of PT for three largest profiles. Gray bar marks 50% percentile of the total number of boardings for all profiles.



Despite infrequent use, travelers repeatedly use the same stops defined as travelers' key activity centers. We estimate the number of stops most frequently used for 50 and 75% of boardings (Figure 4).



As show in Figure 4b, the overall number of visited stops grows almost linearly to 20-22 stops until the number of boardings increases to 95th percentile, while the number of frequently visited stops stabilizes very quickly. One can see that for less than 40 boardings, 50% of boardings are done at 2-3 stops, and 75% at 4 -5 stops.

(a)

(b)

Figure 4. (a) Example of activity centers for two frequent users of the PT (80 boarding, 97th percentile of boardings) (b) Number of visited stops within a certain percentile of the most frequently visited stops as dependent on the total number of boardings, all for working days of the month.

Concluding the above, a well-known fact is that the LOS of Israeli PT is well below the standard of European counterparts. The average velocity in major metropolitan areas is ~15kph vs ~30 kph in the EU, while the priority bus lane length per capita is 14m compared to 300m. We assert that these dire-straits are a possible reason of the highly adaptive behavior of the Israeli PT users that may plan each trip anew. This travelers' behavioral adaptation can work both ways: On the one hand, adaptive PT users can quickly shift to new travel modes, such as ridesharing or two-wheelers (e-bikes and e-scooters that have become increasingly popular in Israel in recent years). On the other, improvement in the PT's LOS can possibly attract those 25+% of users for whom PT is a marginal mode with positive influence on mitigating the metropolitan traffic conditions.

References

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