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Route Choice Preferences of Public Transport Passengers in Different Cities

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Abstract: In public transport network planning, it is essential to know the demands as well as the decision-making aspects of the passengers. A special timetable information and journey planning application has been developed and applied in 17 cities with different sizes and structures in North West Hungary since 2016 which is also able to collect and utilize the decisions of the users. Based on the collected real-life decision data, different logit models have been built for the different cities as well as for different age groups of the passengers. The examined variables are basically the time equivalents for transfers, walking and waiting phases of the journeys. This paper presents the main experiences of this project and the comparison of the decision models constructed so far. Results show clearly the differences between passenger layers of different cities and different ages in many cases, especially in larger cities where a higher amount of data is already available.

Keywords: Public transport, Passenger preferences, Urbanization, Route choice

Introduction

For the planning and development of sustainable public transport systems, it is important to have a deep understanding of the passengers' requirements and decision criteria system (Esztergár-Kiss & Caesar, 2017). To facilitate this, an online local transport timetable and journey planning system called "MenetRendes" was developed. This was used from June 2016 until October 2019 (and partly after that) by the former ÉNYKK Északnyugat-magyarországi Közlekedési Központ (North West Hungarian Transportation Center) Zrt. (reorganized in 2019) in 17 cities of various sizes and types (Ajka, Balatonfüred, Balatonfűzfő, Győr, Keszthely, Körmend, Lenti, Mosonmagyaróvár, Nagykanizsa, Pápa, Sopron, Szombathely, Tapolca, Várpalota, Veszprém, Zalaegerszeg, Zirc, their location is shown in Figure 1.) This created an opportunity to examine passenger preferences by city types (Winkler, 2017). This paper summarizes more than 3 years of operational experience and the scientific conclusions drawn from it, structured as follows. The next section takes a look at the functionalities of the "MenetRendes" software and the types of data the program logged. It will be followed by discussing how the logit decision-making models can be built from the data regarding the decision-making habits of the passengers, and how the models' coefficients can be determined. The section after this will show the usage statistics logged by ÉNYKK since June 2016 and also the decision-making models by cities based on the logged decision data. This will be followed by the preferences of the 6 passenger types (students, workers, pensioners at the start of their travel and during their travel) which are distinguished by the system, based on previous research (Winkler, 2010, 2011, 2013). Finally, the paper will be concluded.

The "MenetRendes" program

The main goal of the "MenetRendes" system (http://menetrendes.hu/) is to display the local (urban) public transport timetables in a unified format, including journey planning options (Winkler, 2010). The program's main functions are:

- displaying the timetable of lines (routes) (for any stop)
- determining and displaying the recommended transfer opportunities
- displaying the list of stops (in various groupings)
- displaying information about the stops (with maps, possibly with pictures, and displaying the lines assigned and the times of the next services)
- displaying the validity and price of tickets and passes by line or line section
- providing connection to various map systems
- providing a multilanguage user interface (ÉNYKK's system contained all information in both Hungarian and English)
- planning the journey.

From the functions above, the last one is the most important with regards to this paper, so it will be discussed in details.

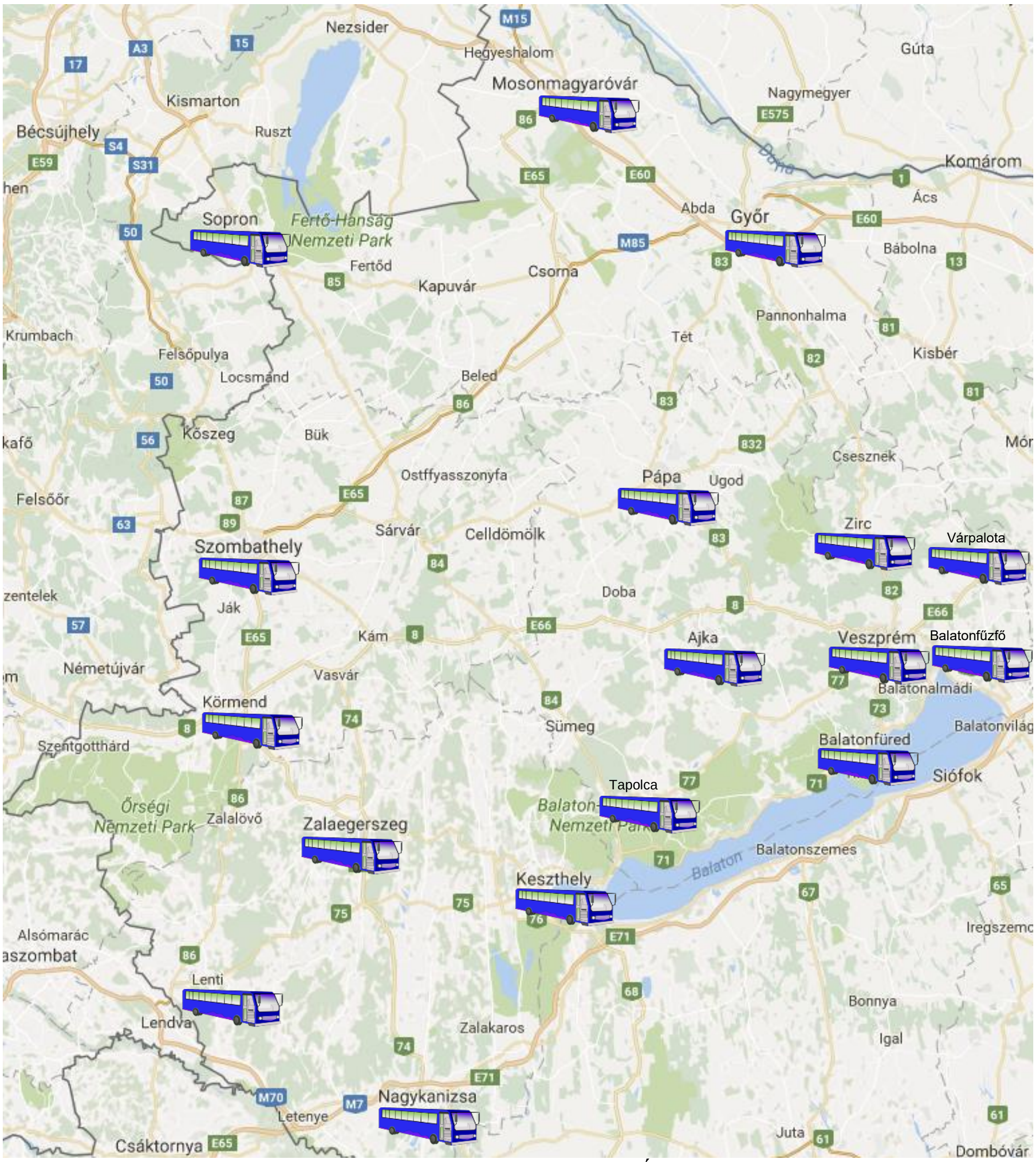

Figure 1. Cities served by the former ÉNYKK Zrt.

After loading the journey planner page (Figure 2), the users can set various parameters (mostly optional):

- first, they have to choose one of the 6 passenger layers that fit them the most

- then, they have to choose a pass type (single line or for all lines) and travel discount (e.g., travel for free) that is used to determine the price of the journey
- if they do not have a pass or ID valid for all lines, they can set the default ticket type for the system to calculate with
- it is enough to set these once for each city: if cookies are allowed in the browser, these setting will be stored
- next, they have to choose the start and end point (based on the closest stop or on the map)
- then, they can set (it's not mandatory) the date and time of the journey, the default is the actual date and time, and other parameters can be set
- lastly, they have to click on the "Planning" button.

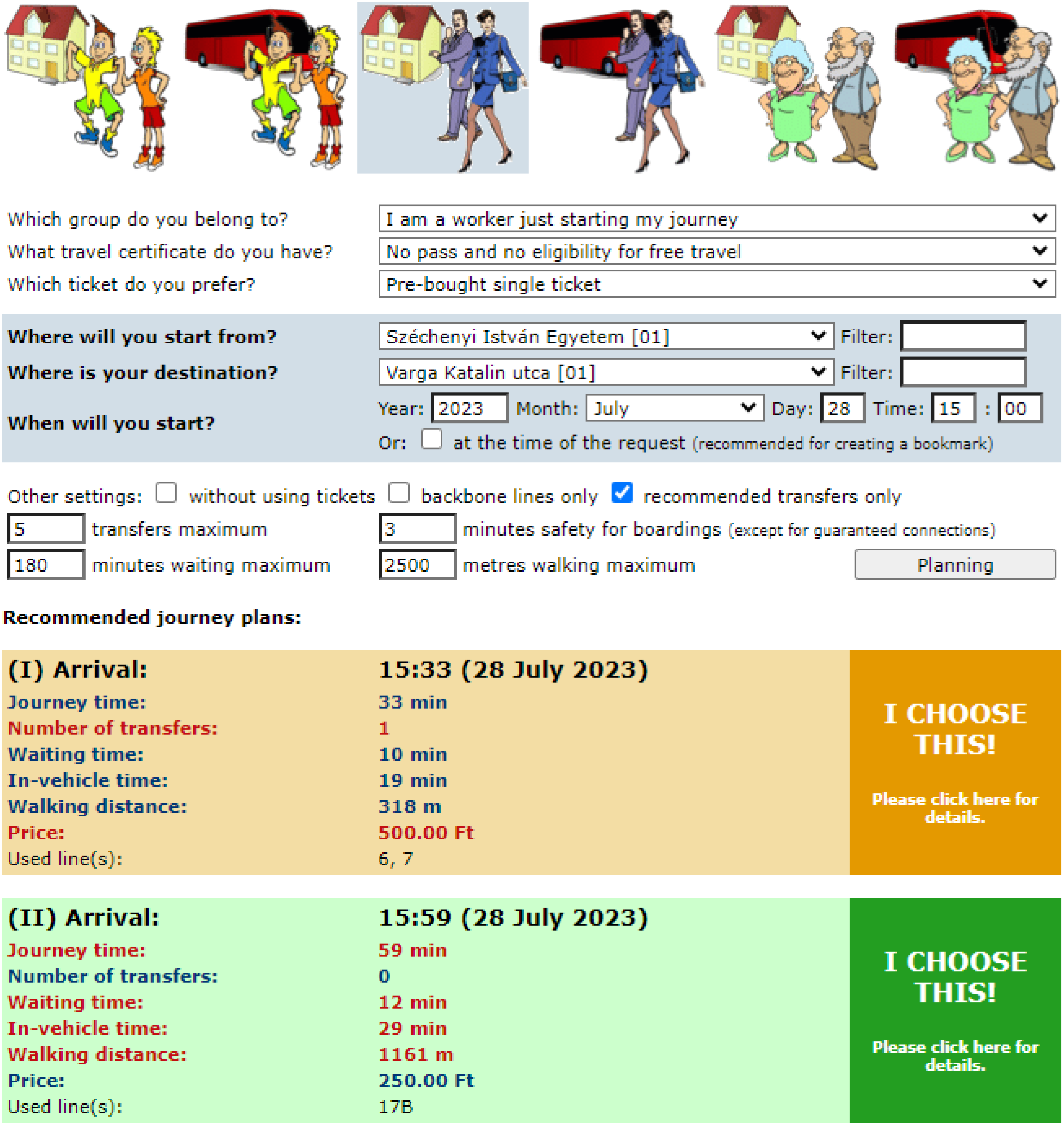

Figure 2. User interface of "MenetRendes" with two alternative journey plans

The software will offer 2 alternative plans as shown on the bottom part of Figure 2 with its main parameters (time of arrival, journey time, number of transfers, waiting time, in-vehicle journey time, walking distance, price of journey) appearing on the bottom of the page. Blue marks the more suitable version, while red marks the less ideal option to aid the choice. For those familiar with the city, there is also a list of bus lines to be used. To display the details of the chosen plan, one has to click on "I CHOOSE THIS!" next to the plan. If, after reviewing the details, the user still prefers the other plan, it is possible to change by clicking on the "I RATHER CHOOSE THIS!" button.

For each choice, the software logs the following data (of course anonymously, it does not identify a specific user):

- query identifier (to manage modified decisions)
- city
- passenger layer
- type of day
- for both alternative journey plans:
  - generalized journey time (other features of the travel plan converted to in-vehicle time equivalent)
  - number of transfers (number)
  - in-vehicle journey time (minute)
  - total walking time (minute)
  - total waiting time (minute)
  - extra costs (HUF)
- the user’s choice.

Building the Decision Models

One of the most commonly used model families for transport decision modelling, logit, was used for model building (Ortúzar & Willumsen, 1990). In case of logit models, the probability of choosing a particular option can be calculated with the following formula:

$$P_{jq} = \frac{e^{V_{j,q}}}{\sum_i e^{V_{i,q}}} \tag{1}$$

where P_{jq} is the probability that q individual chooses option j, and V_{iq} is the observed utility (or cost) of q individual for option i. The five explanatory variables in the current analysis are, in accordance with the system logs explained at the end of the previous section, the following:

- number of transfers
- in-vehicle journey time (minutes)
- total walking time (minutes)
- total waiting time (minutes)
- extra costs (forint).

Based on the above, the utility (or cost) function can be defined as:

$$V_{jq} = TRANSF_q transf_j + \sum VTIME_q vtime_j + \sum WALK_q walk_j + \sum WAIT_q wait_j + PAY_q pay_j \tag{2}$$

where

- $TRANSF_q$ is the coefficient of the number of transfers in case of q passenger (layer)
- $transf_j$ is the number of transfers in case of j journey
- $VTIME_q$ is the coefficient of in-vehicle journey time in case of q passenger (layer)
- $vtime_j$ is the in-vehicle journey time in case of j journey
- $WALK_q$ is the coefficient of total walking time in case of q passenger (layer)
- $walk_j$ is the total walking time in case of j journey
- $WAIT_q$ is the coefficient of total waiting time in case of q passenger (layer)
- $wait_j$ is the total waiting time in case of j journey
- PAY_q is the coefficient of extra costs in case of q passenger (layer)
- pay_j means the extra costs in case of j journey.

The model above as well as data logged by “MenetRendes” (the parameters of alternative journey plans and user decisions) were used to estimate the values of the above coefficients using the BIOGEME software (Bierlaire, 2009), grouping the decisions by city and passenger layer.

Estimating the Coefficients of Decision-Making Models by City

In the examined period, thousands of people used the services of “MenetRendes”, that includes 73,227 journey plans that involved stating their preferences indirectly. However, as seen on Figure 3, the users’ distribution by city was not uniform.

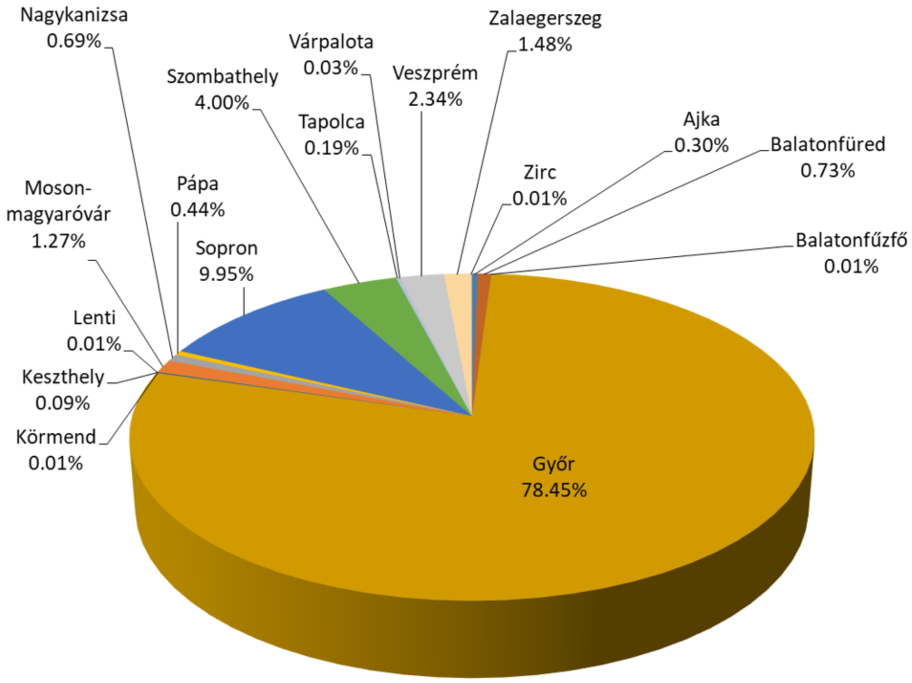

Figure 3. Share of journey planning usage per city

The software was used to plan journeys in Győr with a surprisingly high ratio of 78%. Even though among the examined cities, Győr’s population is the biggest (Table 1), this ratio is still too high, in relation to the population. An explanation could be that the trial version of “MenetRendes” has been available for Győr’s local bus service since 2013, so passengers in Győr have had more opportunities to use the software regularly. For the other newly added cities, the usage rate is already more or less proportional to the population of the cities.

Table 1. Results for different cities

City	Number of decisions processed	Choice rate of primarily recommended journey plan	In-vehicle time equivalent of a transfer (minutes)	In-vehicle time equivalent of 1 minute walking (min)	In-vehicle time equivalent of 1 minute waiting (min)
Ajka	219	76%	not significant	0.69	0.31
Balatonfüred	531	73%	58.89	2.06	0.91
Balatonfűzfő	5	80%	not significant	not significant	not significant
Győr	57,446	78%	20.03	2.46	1.09
Keszthely	69	88%	not significant	not significant	not significant
Körmend	8	63%	not significant	not significant	not significant
Lenti	9	78%	not significant	not significant	not significant
Mosonmagyaróvár	930	82%	not significant	not significant	not significant
Nagykanizsa	507	78%	not significant	not significant	not significant
Pápa	319	83%	not significant	not significant	not significant
Sopron	7,285	80%	24.35	2.66	1.20
Szombathely	2,929	75%	27.19	3.15	1.27
Tapolca	140	72%	not significant	not significant	not significant
Várpalota	23	70%	not significant	not significant	not significant
Veszprém	1,713	77%	14.77	2.37	0.85
Zalaegerszeg	1,082	77%	31.09	3.31	1.26
Zirc	10	18%	not significant	not significant	not significant
All together	73,225	78%	22.37	2.58	1.10

The method introduced above was used to calculate the coefficients of the utility (or cost) function in formula (2) for the corresponding logit model for all 17 cities. Table 1 does not show directly these, but more illustrative values converted to in-vehicle travel time equivalents for transfers, walking and waiting. The "not significant" marking in the table means that BIOGEME could not find statistically significant correlation. This usually occurs with cities for one or more coefficients where few people used the journey planner of “MenetRendes”, so there were few decision-making data logged and analyzed. The analysis of monetary value only produced a significant result in Győr, where the value of 1 hour of travel was 4,544 HUF (~12 EUR), that correlates with previous results (Imam & Chryssanthopoulos, 2012). In the case of other cities, this matter may be the subject of further research.

When analyzing the results, it is useful to check the proportion of users who chose the primary or secondary recommended journey plans. Previous research (Winkler, 2013) concluded that if the discovered passenger preferences were neglected (meaning the only aspect that was regarded was the journey time), 73% of users chose the primary recommended option. With the use of the preference coefficients based on the research on previous decisions of users from Győr, this value reaches 78% in the 17 cities together, as shown in Table 1 and Figure 4. In the future, even better accuracy can be expected using the latest coefficients.

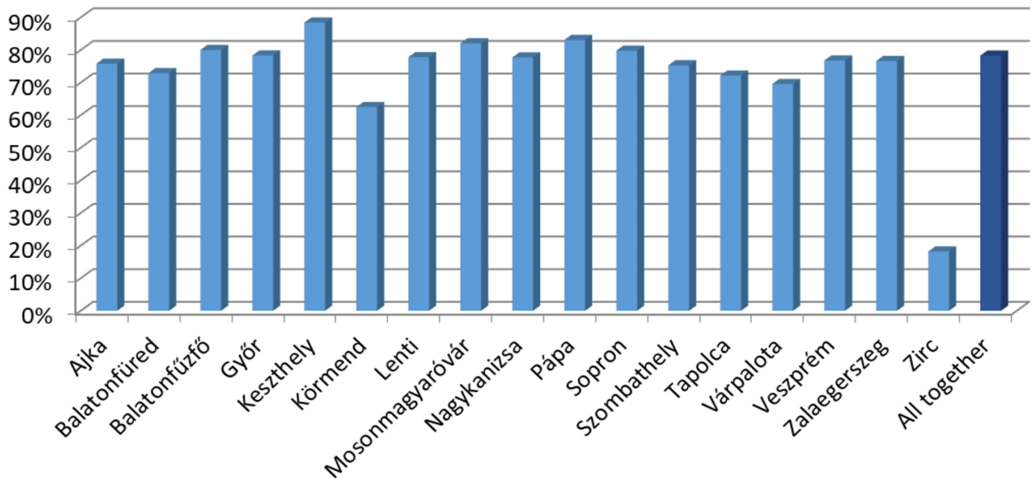

Figure 4. Choice rate of primarily recommended journey plan

The in-vehicle time equivalents which are statistically significant are shown by city in Table 1 and visually illustrated in Figures 5. 6, 7.

Figure 5 shows the in-vehicle time equivalent of transfers: in line with previous research (Sjöstrand, 2001; Winkler, 2013, 2017), the data show that the transfer “penalty” in various cities ranges from 14 to 32 minutes (however, slightly elevated, compared to the earlier results). The only outstanding data was found in Balatonfüred with 59 minutes. However, there is no visible correlation between the size of the cities and the time equivalent of transfers.

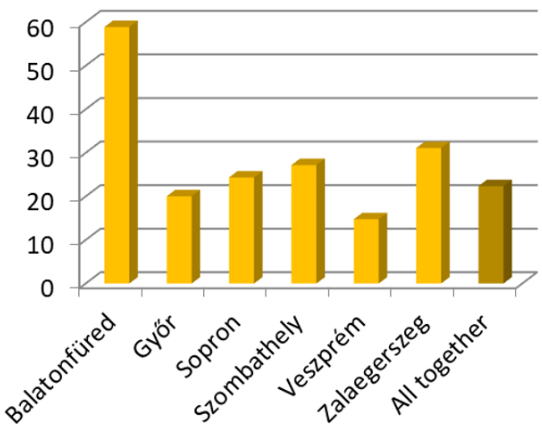

Figure 5. In-vehicle time equivalent of a transfer (minutes)

Figure 6 shows the time equivalent of walking (compared to the time equivalent of in-vehicle journey). Except for Ajka (where presumably the relatively small amount of data, and thus insufficiently representative sample, led to unexpected results) we can conclude, that in each city, time spent walking is a bigger burden for passengers than in-vehicle journey time. The degree of discomfort is described by multipliers ranging from 2.37 (Veszprém) to 3.15 (Szombathely).

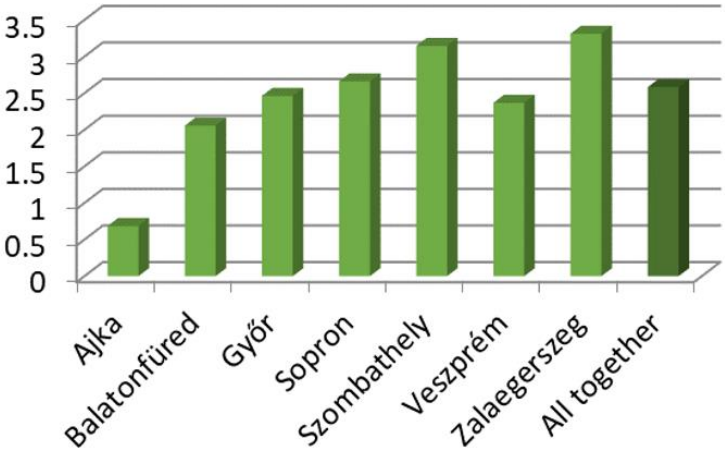

Figure 6. In-vehicle time equivalent of 1 minute walking (minutes)

Figure 7 shows the in-vehicle time equivalent of total waiting time. A particular feature of journey planning programs is that passengers usually do their planning in the comfort of their own homes or workplaces, often before the actual trip starts. As a result, they tend to perceive waiting as less of a disadvantage than if they were already at the bus stop, as they can spend their time in a useful and comfortable way until they actually have to leave for the bus stop. As a result, the calculated time equivalents are less than 1 in several cities, so the result was more favorable than the in-vehicle time. (This is of course truer before the journey starts, less so during the journey, as it will be shown in Table 2.) Due to this anomaly, no correlation was found between the values per city and the characteristics of the cities, and further research could be conducted to eliminate this deviation.

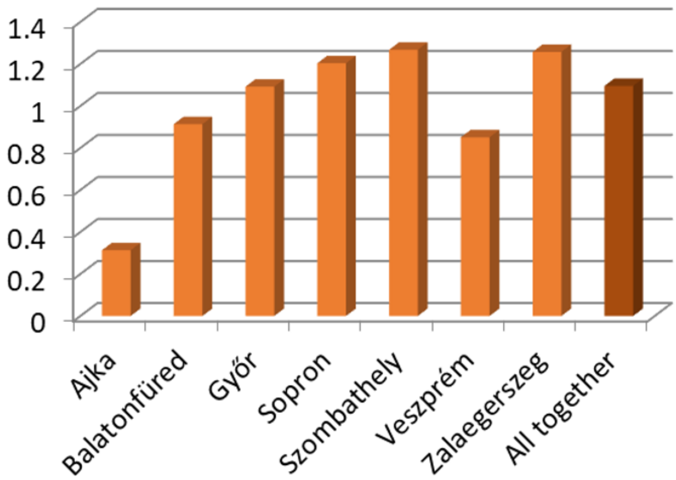

Figure 7. In-vehicle time equivalent of 1 minute waiting (minutes)

Estimating the Coefficients of Decision-Making Models by Passenger Layer

Although the primary focus of this paper is to examine the variation in passenger preferences by city, it was worthwhile to re-examine the coefficients (Winkler, 2013) for the 6 previous passenger layers (all cities combined), to take advantage of the relatively large sample size. The distribution of the logged decisions by passenger layer is shown in Figure 8, while the results of the model estimation with BIOGEME are shown in Table 2.

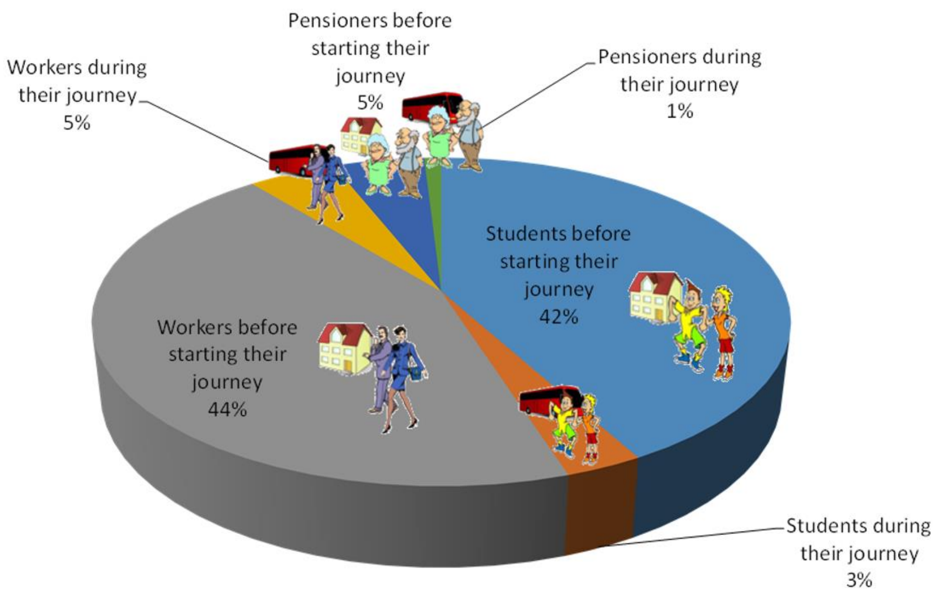

Figure 8. Share of users by passenger layers

Table 2. Results for different passenger layers

Passenger layer	Number of decisions processed	Choice rate of primarily recommended journey plan	In-vehicle time equiv. of a transfer (minutes)	In-vehicle time equiv. of 1 min walking (minutes)	In-vehicle time equiv. of 1 min waiting (min)
Students before starting their journey	30,782	77%	18.10	2.73	1.10
Students during their journey	2,225	76%	20.57	2.79	1.17
Workers before starting their journey	32,269	79%	26.21	2.50	1.08
Workers during their journey	3,563	79%	21.77	2.16	1.00
Pensioners before starting their journey	3,698	80%	16.64	1.68	0.90
Pensioners during their journey	690	76%	24.28	2.23	1.17

As previously mentioned, in case of preferences taken up during the journey, the coefficient of waiting time is typically higher compared to the in-vehicle time. This is understandable as the waiting time that comes with transfers cannot be used for any other purposes, and the circumstances would be less comfortable as waiting at the starting point (home, workplace). Similar results have been received for transfers and walking, apart from a few anomalies that would be expected to disappear if an even larger sample size could be used.

Conclusion

The paper introduced "MenetRendes", an online system containing urban public transport timetable information and journey planning, and discussed operational experiences from 17 cities that were served by the former ÉNYKK Északnyugat-magyarországi Közlekedési Központ (North West Hungarian Transportation Center) Zrt. Based on 3+ years of experience, logit decision-making models were built that describe the criteria system of passengers in different cities and users from different passenger layers. The studies have shown certain correlations, confirming previous research results, although for several cities the amount of data recorded was not sufficient to achieve statistically significant results, and in some cases (typically also in the small sample size cities) the results were different from those expected and less realistic. For these reasons, a more detailed analysis with different passenger layers inside the cities is not actual as this would lead to even smaller sample sizes and thus even less significant results. However, the results discussed above already show that the system can be used to discover the preferences of public transport users with the goal of designing increasingly high-quality public transport services and information systems.

Scientific Ethics Declaration

The author declares that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the author.

Acknowledgements and Notes

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