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Investigating the stated willingness-to-wait to avoid crowding in public transport with real-time crowding information

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**Abstract**

The objective of this study is to investigate the potential travel behaviour impact of potential access to real-time crowding information (RTCI), manifested in form of induced propensity to wait for less-crowded urban public transport (PT) services. RTCI is a novel but increasingly feasibly feature in ITS-driven transport solutions that could serve as a useful travel demand management tool in urban PT networks – however, little remains known about its exact influence on passengers’ travel experience and system performance.

This paper aims to address this research gap and presents results from focus-group discussions and field surveys conducted among urban PT users in the city of Krakow (Poland). Our research study focuses on investigating factors associated with passengers’ perceptions and experience of PT crowding that might affect their attitudes towards crowding information. Selected conclusions from in-depth discussions in focus groups allow us to understand the passengers’ interpretation of various RTCI representation methods and main reasons underlying their decisions to utilise crowding information. The main stage of our investigation involves the stated-preference (SP) experiment conducted among PT users in Krakow, where we analyse passengers’ preferred choices in response to (yet hypothetical) RTCI on the on-board crowding levels. We outline relevant correlations with various trip- and population-related characteristics, noting e.g. the impact of prior crowding experience, trip duration and frequency, users’ demographics etc. Additionally, the obtained SP results are used to estimate a generic discrete choice model describing the stated “willingness-to-wait” to reduce overcrowding in urban PT systems.

The ultimate objective of our research work is to provide useful contribution for future real-time crowding information systems. We hope that findings included in this study could indicate issues relevant for developing RTCI as an efficient PT network management solution.

*Keywords:* public transport; crowding; passenger congestion, real-time crowding information; RTCI

**Introduction**

Passenger congestion (overcrowding) is one of essential factors determining the overall quality of public transport service and passengers’ travel experience in numerous ways. In this context, an increasingly interesting and promising solution might be offered by modern ATIS developments, which would soon allow to provide passengers with real-time information (RTI) on current crowding conditions in public transport networks. These systems are currently in their early (trial) deployment stages, and a crucial issue in their development is how such sort of travel information (advice) would impact passengers’ travel strategies. To the best of our knowledge, this is an extensive yet not fully investigated research field, which we try to address (to a certain extent) with this study.

The influence of real-time travel information (RTI) availability upon passengers’ travel behaviour is commonly acknowledged by literature sources dealing with the ATIS systems’ impact in public transport networks. Travelers are nowadays provided with numerous, ubiquitous RTI sources for trip planning purposes (Ben-Elia (2013)), though the state-of-the-art knowledge on RTI effects on demand side remains fairly limited. This notion has been more explored in case of RTI on travel times – where survey- and simulation-based studies underlined potential consequences in terms of behavioural responses and implications for output network performance (Cats et al. (2011), Fonzone and Schmoecker (2015)). However, the amount of research work on the RTI on crowding conditions is yet more limited. Individual papers dealt with its impact investigation in terms of simulation approach (Nuzzolo et al. (2016), Drabicki et al. (2017)); empirical studies concerning pilot implementation of such system (Zhang et al. (2015)) and stated-choice experiment (Preston et al. (2017)) shed some light onto (respectively) passengers’ attitudes towards displaying RTI on train carriages’ crowding levels and propensity to accept extra waiting time in regional (long-distance) rail system. Kim et al. (2009) reported that a substantial share of bus users would be willing to skip the first departure at stop and wait for the next, much less crowded one. Finally, there is an abundant amount of literature on crowding valuations in public transport systems and the associated “willingness-to-pay” to reduce crowding, evaluated both in SP and RP approaches (e.g. Tirachini et al. (2013), Whelan and Crockett (2009)). Results in these studies are mostly derived as in-vehicle travel time factors though, with limited research regarding the waiting-time trade-offs (e.g. Wardman (2014)), and WTP estimates are often related to the generic (and long-term) impact of crowding in PT networks.

**Research contribution**

The contribution of this work would be to provide an evidence-supported insight into what might be passengers’ propensity to adapt travel strategies with response to real-time crowding information in urban PT networks. Our SP-based investigation, comprising PT user surveys, would indicate the stated willingness to accept additional waiting time to mitigate the anticipated on-board crowding conditions and how it is influenced by specific trip-related (e.g. trip duration, transport mode, service frequency) and socio-demographic characteristics. Survey responses would allow to evaluate the common perception of “overcrowding” threshold triggering the temporal shifts towards less-crowded services, and our discrete choice model estimates could serve as useful guidance (and input) for analytical and modelling purposes. We hope that findings from this study could enrich the understanding of objectives associated with providing the RTCI to passengers – and thus comprise a beneficial contribution to the state-of-the-art research on developing effective travel demand management and ATIS solutions in modern-day public transport networks.

**Methodology**

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| **Q9: Which of these departures would you be willing to choose for your current trip?**  - journey time: ***20*** [mins], departures every: ***10*** [mins],  - need to arrive on-time: ***YES***, trip purpose: ***home 🡺 work*** | |
|  | 1st dep.: no seats available, but can stand comfortably |
| 2nd dep.: seats available |
| **A9:** [ ] **1st departure** – NOW / [ ] **2nd departure** – in 10 minutes | |

Fig. 1. Sample SC experiment question from the survey questionnaire.

To fulfill our research objective, we carried out first a series of focus-group discussions (mostly involving students and PT system users in Krakow). Focus-group discussions provided an in-depth insight into respondents’ various associations and expectations of overcrowding in PT journeys, potential ideas about future RTCI system and therefore served both as an input for the final survey questionnaire design, as well as provided interesting findings complementing the eventual picture of our analysis. Afterwards, the main stage of our investigation involved a series of SP at-stop surveys conducted among urban PT system users in the city of Krakow (the second-largest city in Poland with ca. 750k population). Survey questionnaire starts with questions related to passengers’ prior experience of crowding effects, which are then followed by the core part of the survey. It is designed a stated-choice (SC) experiment, where passengers are presented with hypothetical RTCI values for their next trip departures and are asked to indicate their preferred choices.

Results gathered from the SP survey are then subject to statistical analysis. Basically, the reported answers should reveal the acceptable trade-offs between additional waiting time vs. reduction in crowding conditions and correlation with the specific choice settings – i.e. influence of various trip- and population-related properties, including: trip duration, service frequency, trip purpose and time-criticality, in addition to users’ demographic data, familiarity with travel route and expectations of crowding discomfort. Apart from deriving statistically relevant correlations, the results’ sample is further used as a basis for estimating a generic choice model, which aims to describe the probability (stated willingness) to “trade” additional waiting time in exchange for boarding a later but less-crowded PT line departure. The model is estimated as a discrete MNL choice model using the BIOGEME analytical toolbox, where probability of boarding a second PT vehicle (of a given crowding level) is evaluated as a function of: crowding level in the first PT vehicle (departing now), the required waiting time and additional explanatory variables relevant in the specific choice context.

**Preliminary results and discussion**

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| **crowding information level (1-to-4 scale)** | **respondents’ interpretation** |
|  | - severely overcrowded, could barely find a grip, hard to stand  - need to be lucky to “squeeze” inside, might not board; should consider different travel options |
|  | - overcrowded, no seats available but could stand comfortably  - would take this trip, but expect some discomfort |
|  | - last few seats available (less than 10%), might not get them  - wouldn’t “mind” seeking a comfortable standing place |
|  | - multiple (over 50%) seats available  - expect to find a double seat just for myself; would choose this trip “at-ease” |

Fig. 2. Sample focus-group results – common interpretations of crowding conditions on-board for a hypothetical, 1-to-4 RTCI scale in urban public transport system.

As part of our research project we have already conducted a series of focus-group discussions and the main stage of at-stop SP surveys is gradually being finalized (at present containing over 400 valid responses). These already provide preliminary findings and observations that we summarise below:

1. Focus-discussions reveal the most common objectives of travel advice on on-board crowding sought by passengers, dependent generally on their necessity to arrive on-time at the destination: for time-critical trips, travelers would be mostly interested in information on possible denial-of-boarding risk, whereas for non-time-critical trips there seems to be a bigger emphasis on obtaining information about seats available and/or reduced “standing” crowding conditions. Other conclusions include the predominant perception of “overcrowding” threshold being related to conditions described as “hard and uncomfortable to stand on-board”.

2. In terms of crowding information representation, we noticed main preference towards a descriptive rating scale (analogous to “red-amber-green”). Such method of displaying RTCI exhibits simplicity and clarity in respondents’ interpretations (as shown for sample case in fig. 2) and trip planning purposes, while also being adequate for urban PT journeys. Otherwise, numerical information on seats available seems popular for long-distance and train journeys – though displaying information on a percentage scale is the least favourable option, raising a number of issues among our respondents (complexity in interpretation, lack of clear indication of standing or seating conditions without prior suggestion, or even an induced feeling of a “gambling” risk – “might get a seat or not”).

3. The stated propensity to wait to avoid crowding is evidently dependent on crowding conditions in the first departure reaching a specific threshold of overcrowding. Summary of our SP results so far (fig. 3) shows that, with hypothetical access to RTCI, majority of passengers are especially likely to accept additional wait for a second, less-crowded departure if the first arriving vehicle is highly overcrowded. This stands in clear contrast with the scenario where RTCI for the first departure is “reduced” to moderate crowding conditions, and availability of seats in the second departure induces only a very limited willingness-to-wait, with max. acceptance of no longer than extra few minutes.

4. However, a more detailed statistical analysis of our results has demonstrated that certain factors can substantially affect the (stated) willingness-to-wait to reduce on-board crowding. This concerns for example specific trip purposes (leisure trips) and age groups (respondents aged 50 and over), where we could observe a higher propensity to follow the RTCI advice even for moderate crowding conditions. In contrast, trips which are rather “insensitive” to crowding information include time-critical trips, younger travellers, and interestingly – frequent travelers and those with greater prior experience of PT overcrowding.

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| *case [a]:*  *1st run ●●●●*  *– severe overcrowding, might not board*  *2nd run ●●●*  *– moderate crowding, can stand comfortably* |
| *case [b]:*  *1st run ●●●*  *– moderate crowding, can stand comfortably*  *2nd run ●●*  *– minor crowding, can sit* |
|  |

Fig. 3. Preliminary results from SP surveys – stated choices between first vs. second (less-crowded) line run (departure) with hypothetical RTCI in current choice context.

The results presented in this abstract are a “proof-of-concept” of our analytical works, which are currently in progress, and whose final results will be presented at the Symposium.

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