CASPT 2022

Share of Strategic Alighting Passengers combining Automatic Passenger Counting and OpenStreeMap

Extended Abstract

Rémi Coulaud · Valentine Mazon · Laura Sanchis · Oded Cats

Abstract Understanding passengers' distribution on-board trains and along public transport platforms is crucial for improving service's performance and ensure passengers' comfort. We propose a revealed preference measure of passengers alighting behaviours using automatic passenger counting (APC) data. Our findings revealed that the share of strategic alighting passengers per station is influenced by its layout and the overall passengers volume at this given station.

Keywords Passenger counts, strategic alighting passenger, passenger behaviour, passenger distribution, empirical study

1 Introduction

In public transports, most passengers board and alight neither randomly, nor uniformly, leading to very heterogeneous crowding inside trains and along public transport platforms. Yet, one critical overcrowded zone of a platform or a train can have great impact on many aspects of the service (e.g., dwell time, service punctuality, passengers' comfort). Hence, crowding has long been recognised both as an indicator of public transport performance as well as an important measure of passenger satisfaction with the service (Szplett and

Rémi Coulaud
Université Paris-Saclay, CNRS, Laboratoire de mathématiques d'Orsay
Orsay, France
E-mail: remi.coulaud@sncf.fr

Valentine Mazon and Laura Sanchis
SNCF Voyageurs – Transilien
Saint-Denis, France

Oded Cats
Department of Transport and Planning, Delft University of Technology
Delft, The Netherlands

Wirasinghe, 1984; Kim et al, 2014; Börjesson and Rubensson, 2019). A deeper understanding of passengers' flow and distribution in public transports became all the more crucial with the COVID pandemic, since these flows were rapidly and constantly changing, as a consequence of evolving governmental restrictions undertaken in all countries. To tackle this issue, many studies have focused on understanding the underlying reasons that give rise to the emergence of passengers' uneven distribution along platforms and how crowding valuation can influence their route choice (Drabicki et al, 2021). Most of these studies, reported in Table 1, rely either on stated preferences collected through field surveys, or revealed preference obtained from passenger count data.

Among the few studies exploring passengers' positioning choice through stated preferences is the one reported in Kim et al (2014). Results revealed that 53% of passengers intentionally choose a specific car with the aim of minimising walking distance at their destination station. These findings were later confirmed by Elleuch (2019) who found a very similar share (54%) for Paris region. We then refer to these passengers as strategic alighting passengers (SAP). Finally, Szplett and Wirasinghe (1984), Krstanoski (2014) analysed alighting and boarding distribution using revealed preferences data only, namely manual counting measures. They noticed that passengers' distribution is significantly influenced by the station layout. Our principal contribution lies within the proposed methodology – quantifying the proportion of strategic alighting passengers, using exclusively automatic passenger counting (APC) and OpenStreetMap mapping data, thus enabling a larger temporal and spatial study scope.

Table 1: Literature review on passenger's behaviour on-board and at the train-station interface

Authors	**Study interest**	**Data collection**
Kim et al (2014)	Boarding	Survey
Elleuch (2019)	Boarding	Survey
Szplett and Wirasinghe (1984)	Boarding/Alighting	Manual counting
Krstanoski (2014)	Boarding/Alighting	Manual counting
Drabicki et al (2021)	Boarding/Alighting	
Our study	**Alighting**	**APC**

2 Measuring willingness to minimise walking distance at station

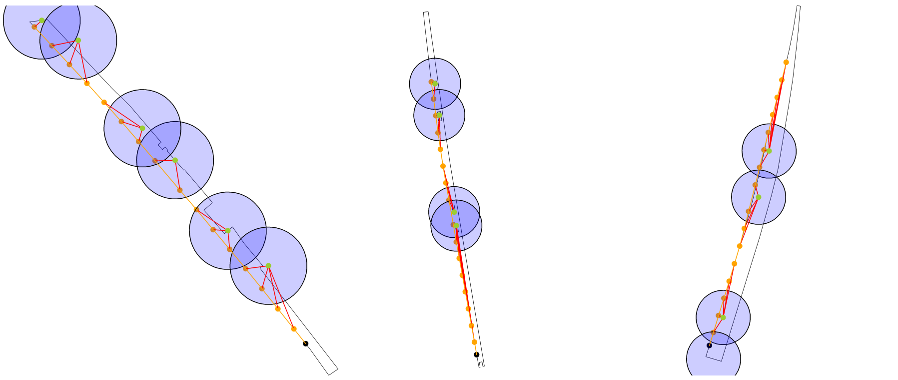
We build a method to compute SAP based on revealed preference through APC counts per door. The quality of APC data was confirmed by a field survey revealing a 95% precision for alighting $a^i_{k,s,d}$ and boarding $b^i_{k,s,d}$ passengers measure per door $i \in \{1, \ldots, I\}$ for each stop defined by a train number k, a station s and a day d.

In order to analyse SAP, we link each door identifier to its precise location along the platform and consequently, its distance to all platforms exit points. We use OpenStreetMap (OpenStreetMap contributors, 2017) to retrieve the platform layout: borders, exit and entrance points. Finally, we use stop signal location and rolling stock characteristics to deduce doors' location on platform as illustrated in Figure 1. For each station, we define doors V_s^i and exits E_s^j coordinates. We then compute for each door i and each station s, the distances to all platform exits j: $d(V_s^i, E_s^j)$ and identify, for each door of a train, the distance to the nearest platform exit noted $d^i_{s,min}$.

$$d^i_{s,min} = \min_{j=1,\dots,J} d(V_s^i, E_s^j)$$

The distance used is the great circle distance based on the spherical reference of earth WSG 84, displayed in red in Figure 1.

We then search the number of passengers choosing to minimise their walking distance once arrived i.e the share of alighting passengers near platform exits. We define the platform exit attractiveness as a circle area of radius r (meters) centred around the platform exit location, the blue circles in Figure 1. We assume that all platform exits have the same attractiveness.



(a) Epinay-Villetaneuse (b) Saint-Denis (c) Paris gare du Nord

Fig. 1: Platform graph with a 20 meters exit attractiveness for three different platforms used by trains running from the suburbs to Paris. We display several components: • Exit location; ○ 20 meters exit attractiveness; • Stop signal location; • Door location; – Distance to the nearest platform exit per door.

Once these areas are set, we categorise doors into strategic or not. A door $i \in \{1, \dots, I$ is strategic if it belongs to an exit attractiveness area; that is, a door located within r meters of an exit: $d^i_{s,min} \leq r$. Finally, we derive the share of SAP with respect to a given exit attractiveness r:

$$SAP_r = \frac{\sum_{i \in \mathcal{I}} a^i_{k,s,d}}{a_{k,s,d}}$$

where $a_{k,s,d} = \sum_{i=1}^{I} a^{i}_{k,s,d}$ is the total number of alighting passengers for one stop. SAP_r will always be an upper bound of SAP because we do not control for boarding position as we do not know origin of the alighting passengers and rolling stocks are car communicant (i.e, passengers can move within the same consist).

3 Share of strategic alighting passengers and its variability in space and time

We compute the share of SAP for the first 6 stations of Line H, see Figure 2, using APC data per door from the 1^{st} of April to the 30^{th} of June 2019. We discard one-unit trains because their stop signal position may vary from two units' trains. In total, the dataset contains observations from 31,000 train stops going from the suburbs to Paris and 31,300 train stops going from Paris to the suburbs. We first determine the right exit attractiveness radius to compute the share of SAP.

In Figure 3, we present the variability of SAP per stations as a function of exit attractiveness. The observed differences are mainly due to the varying exits number by platform and their location. For instance, as shown in Figure 1, Epinay-Villetaneuse platform for trains running to Paris has many exits, which are well distributed along the platform such that the share of SAP increases rapidly while it is not the case for Saint-Denis or Gare du Nord. An exit attractiveness of 20 meters seems just enough to be consistent with previous studies exploring this phenomenon using stated preferences which found a SAP share of 54%.

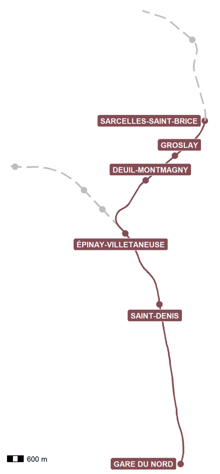


Fig. 2: Spatial perimeter of the study on line H

The proportion of SAP is not only influenced by the platform layout, but also fluctuates during the day. From Figure 4, we see that for trains running to Paris, the proportion of SAP is the highest during morning rush hours for Saint-Denis but not for Gare du Nord. The same result was observed for trains running to the suburbs, as the SAP for Groslay is the greatest during evening rush hours but not for Sarcelles-Saint-Brice. We believe this result for Gare du Nord and Sarcelles-Satin-Brice is mostly due to a large increase in alighting passengers' volumes, which prevents passengers from intentionally choosing a specific car to alight, due to on board crowding conditions. Indeed, in Figure 5, we see a clear effect of alighting passengers' volume on the proportion of SAP, which decreases by 10-20 points when comparing situations with few and many alighting passengers.

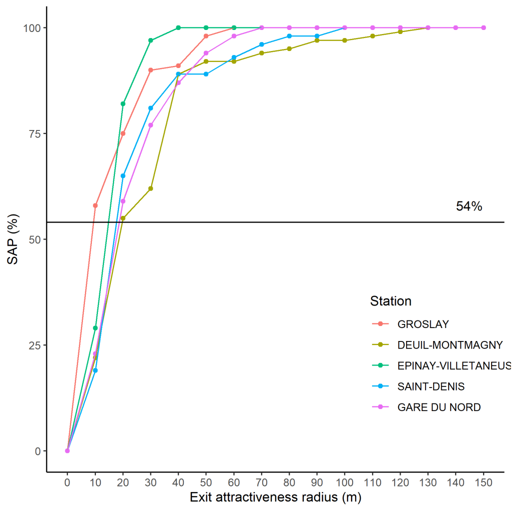
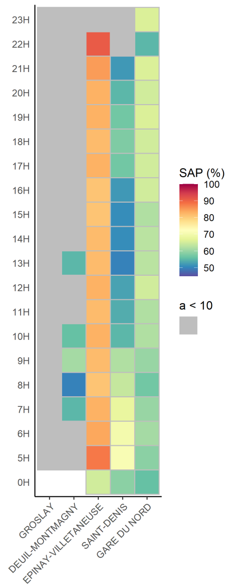
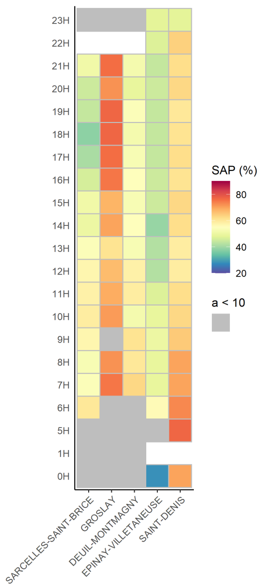


Fig. 3: Share of SAP per station with respect to a uniform 10m increase of exit attractiveness. The studied rolling stock has doors that are 13.2m apart so 10m is almost equivalent to adding a door. The 54% line represents Kim et al (2014) previous findings regarding the share of SAP.

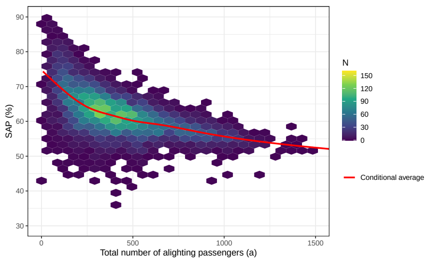


(a) Suburbs to Paris

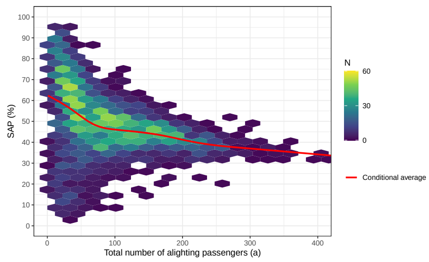


(b) Paris to the suburbs

Fig. 4: Share of SAP_{20m} on 6 stations during working days for trains running from the suburbs to Paris (left) and from Paris to the suburbs (right). Grey periods have an average number of alighting passengers by stop below 10.



(a) Paris Gare du Nord for trains running from the suburbs to Paris



(b) Sarcelles-Saint-Brice for trains running from Paris to the suburbs

Fig. 5: Share of SAP with an exit attractiveness of 20m with respect to the total number of alighting passenger for two selected platforms. The conditional average is depicted in red and is computed through generalised additive models.

4 Outlooks

In this work we propose an intuitive way of computing the share of SAP using APC data. We see three directions to go further: (i) we want to improve the SAP indicator taking into account the platform layout where alighting passengers board; (ii) we want to model the effect of volume and time of the day on SAP; (iii) we will design a method to locate exits using only on APC data.

References

Börjesson M, Rubensson I (2019) Satisfaction with crowding and other attributes in public transport. Transport policy 79:213–222

Drabicki A, Kucharski R, Cats O, Szarata A (2021) Modelling the effects of real-time crowding information in urban public transport systems. Transportmetrica A: Transport Science 17(4):675–713

Elleuch F (2019) Transférabilité d'une modélisation-simulation multi-agents: le comportement inter-gares des voyageurs de la sncf lors des échanges quai-train. PhD thesis, Conservatoire national des arts et metiers-CNAM

Kim H, Kwon S, Wu SK, Sohn K (2014) Why do passengers choose a specific car of a metro train during the morning peak hours? Transportation research part A: policy and practice 61:249–258

Krstanoski N (2014) Modelling passenger distribution on metro station platform. International Journal for Traffic & Transport Engineering 4(4)

OpenStreetMap contributors (2017) Planet dump retrieved from https://planet.osm.org . https://www.openstreetmap.org

Szplett D, Wirasinghe S (1984) An investigation of passenger interchange and train standing time at lrt stations. Journal of advanced transportation 18(1):1–12