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Train commuters' scheduling preferences: Evidence from a large-scale peak avoidance experiment☆

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ABSTRACT

We study the trip scheduling preferences of train commuters in a real-life setting. The underlying data have been collected during large-scale peak avoidance experiment conducted in the Netherlands, in which participants could earn monetary rewards for traveling outside peak hours. The experiment included ca. 1000 participants and lasted for multiple months. Holders of an annual train pass were invited to join the experiment, and a customized smartphone app was used to measure the travel behavior of the participants. We find that compared to the pre-measurement, the relative share of peak trips decreased by 22% during the reward period, and by 10% during the post-measurement. By combining multiple complementary data sources, we are able to specify and estimate (MNL and panel latent class) departure time choice models. These yield plausible estimates for the monetary values that participants attach to reducing travel time, schedule delays, the number of transfers, crowdedness, and unreliability.

1. Introduction

The Netherlands, being one of the most densely populated countries, has one of the busiest railway networks. Recent trends suggest that demand for train travel will still grow further: between 2000 and 2012, the number of railway passenger kilometers rose by 19%, while during the same period car travel increased only by 3% (KiM, 2013, pp. 32,39). The modal share of trains is particularly high for medium- and long-distance commutes and for commutes between the major Dutch cities (Schwanen et al., 2002). Especially in the western and central parts of the Netherlands (comprising the cities of Amsterdam, Rotterdam, The Hague, Leiden and Utrecht) the supply of train services is close to capacity during peak hours, both in terms of network and train capacity (van Vuuren, 2002). The resulting crowdedness leads to discomfort among passengers, mainly due to a lack of empty

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seats and personal space (e.g. Li and Hensher, 2011). Moreover, the large number of people boarding and leaving the trains may lead to longer travel times as well as lower levels of reliability.

Clearly, crowdedness can be reduced by increasing (train and rail network) capacity. However, capacity expansion may not be the most cost-efficient solution, especially when demand is strongly concentrated during peak hours, meaning that the additional capacity will be largely idle outside the peak periods.[1] An alternative to expensive additions to the rolling stock and infrastructure amendments are fares that differ by time of day. The basic idea is that discounted off-peak tickets induce some travelers to shift their trips from peak to off-peak periods, hence decreasing crowdedness during peak hours – while avoiding the costs that would accrue for capacity expansions.

Such time-differentiated charging schemes tend to be beneficial not only from the perspective of the train operators, but also from a social welfare perspective. The main reason is that higher fares during the peak periods lead to an internalization of the external crowding costs, which the passengers impose on each other. In the context of car travel, time-differentiated pricing schemes have been investigated and advocated by transport economists since the publication of the seminal paper by Vickrey (1969). In his paper, Vickrey introduced the well-known bottleneck model, which assumes that travelers make a trade-off between travel time and schedule delays (i.e. the disutility of arriving at the destination earlier or later than preferred) when deciding on their departure time. If the preferred arrival times are similar across travelers (for instance due to common working hours), demand may exceed road capacity and as a consequence congestion will form. In equilibrium, those drivers who arrive earlier or later than preferred will have shorter travel times and longer schedule delays than those that arrive close to their preferred arrival time.

In Vickrey's modeling framework, under first-best conditions, congestion can be fully eliminated by using tolls that vary by time of day. A recent paper by de Palma et al. (2015) shows that similar results can be derived for public transport when a trade-off between schedule delays and crowding applies. The application of an optimal charging scheme will then lead to a more uniform distribution of travelers between train connections compared to the user equilibrium, however, without fully eliminating crowding. Moreover, time-differentiated fares might also be beneficial from an environmental perspective: Rietveld (2002) argues that the marginal environmental costs are higher for peak train travelers than for off-peak train travelers when the off-peak supply of train capacity is determined to a large extent by the demand during the peak period. Time-differentiated fares that are higher during peak periods will then contribute to the internalization of the environmental costs.

The Dutch National Railways (Nederlandse Spoorwegen) recognized already in the late 1980s that time-of-day-dependent ticket prices may be a more cost-efficient alternative to expensive capacity expansions. They introduced the so-called 'Rail-Aktief-Kaart', which granted a 40% discount on single tickets for off-peak trips, and still exists today (under the name 'Dal Voordeel abonnement'). While the 'Rail-Aktief-Kaart' allows for time-differentiated pricing for single trips, the 'peak avoidance experiment' ('Spitsmijden' in Dutch) discussed in this paper is targeted at regular Dutch train travelers (typically commuters) who hold annual train passes. At the core of the experiment is a (distance-dependent) reward scheme, which grants monetary rewards for each trip outside the morning and evening peak hours. The peak avoidance experiment took place between summer 2012 and spring 2013, including more than 1000 active participants. Pre-condition for participation was a valid annual travel pass for a specific OD-pair or for the entire Dutch railway network. The travel behavior of the participants was measured via a customized smartphone app, which continuously recorded the global positioning system (GPS) coordinates, and hence allowed for a direct measurement of their travel behavior.

Besides the reward period of 22–25 weeks, the travel behavior of the participants was also measured during a 3-week period of pre-measurement and a 4-week period of post-measurement. This renders it possible to identify the effect of the reward incentive on the travel behavior of the participants. In order to get the rewards paid out, the participants additionally had to fill in various surveys as well as logbooks. These complementary, high-quality data sources are used to gain further insights into the socio-economic characteristics of the participants, and their (usual and preferred) scheduling behavior and preferences. Together with the travel information provided by an app that is made available by the Dutch National Railways (NS), they render it feasible to estimate full-fledged scheduling choice models, including definitions of the following attributes of the departure time choice alternatives: rewards, travel time, schedule delays, number of transfers, crowdedness (as a proxy for comfort) and unreliability. Due to the presence of the time-of-day-dependent rewards, the monetary valuations associated with improvements in these attributes can be derived. Both multinomial logit and panel latent class models are estimated.

So far, most existing research on the monetary valuation of train travel attributes[2] has focused only on a small number of travel attributes, resulting in models that are less comprehensive than the ones presented in this paper. For instance, Douglas and Karpouzis (2006), Basu and Hunt (2012) and the meta-analysis of Wardman and Whelan (2011) concentrate on crowding in trains, Liu et al. (1997) on transfers and Rietveld et al. (2001) on travel time reliability. A more comprehensive picture on valuations in train travel can be obtained from the meta-analyses on public transport valuations by Wardman (2001); 2004). These two papers by Wardman provide an overview of a large number of (mainly British) public transport valuation studies, accounting for most of the relevant travel attributes (except for comfort valuations). To a large degree these valuations are reported separately for train travel (as opposed to other modes), rendering them especially relevant in the context of this paper.

[1] In the Netherlands, the concentration of train trips during peak periods is rather high, e.g. 24% of all public transport trips longer than 10 km (a majority of which are made by train) take place during the morning peak, but only 13% of all car trips (KiM, 2013, p.38).

[2] Extensive literature exists on the valuation of travel attributes in general, especially in the context of road transport. Recent meta-analyses can for instance be found in Shires and De Jong (2009) (on the value of time), Carrion and Levinson (2012) (on the valuation of reliability) and Li and Hensher (2011) (on the valuation of comfort).