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Crowding in public transport: Who cares and why?

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ABSTRACT

Crowding on public transport (PT) is a major issue for commuters around the world. Nevertheless, economists have rarely investigated the causes of crowding discomfort. Furthermore, most evidence on the costs of PT crowding is based on trade-offs between crowding, travel time and money. First, this paper assesses discomfort with PT crowding at various density levels across heterogeneous individuals using a different methodology. Based on a survey of 1000 Paris PT users, the negative relationship of in-vehicle density on reported satisfaction is similar to previous studies investigating PT crowding costs and stable across most individual characteristics. We also find a sensitive increase in crowding costs over users' income. Second, we investigate the causes of this discomfort effect. We identify three key drivers: (a) dissatisfaction with standing and not being seated; (b) less opportunities to make use of the time during the journey; (c) the physical closeness of other travelers *per se*.

1. Introduction

Given the low elasticity supply of rail-based public transport (PT), policies implemented to reduce individual motorized traffic in cities have often coincided with less comfortable travel conditions. This indirect consequence of modal shift policies is problematic because availability of space in vehicles is often singled out as one of the most desirable dimensions of PT attractiveness. Using factor analysis or structural equation modelling on survey data, various studies have thus highlighted that crowding is a major component of PT users' satisfaction and service quality, next to travel duration, connectivity of the network, service frequency and fares (see Eboli and Mazzulla, 2007; Dell'Olio et al., 2011; de Ona and de Ona, 2015). For instance, Cantwell et al. (2009) decompose satisfaction for PT into three elements – crowding, travel time reliability and monetary cost – and test their relative importance using an on-line survey on commuting in Dublin. Satisfaction levels among PT commuters are strongly decreasing for those who travel in crowded situations.

Crowding negatively affects the passenger experience for several reasons (see Tirachini et al., 2013, for a review). It is associated with increased anxiety (Cheng, 2010) and stress (Mahudin et al., 2011), especially if it implies proximity to other passengers (Evans and Wener, 2007) or propensity to arrive late for work (Mahudin et al., 2011). Crowding might also accentuate the perception of risk to personal safety and security (Cox et al., 2006). Moreover, crowding is important for workers' choices about working times (Tirachini et al., 2013) and for firms' scheduling of working hours (Henderson, 1981).

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Recognizing these discomfort effects, theoretical models of public transport increase the cost of time in crowded PT – either discretely once passengers can no longer be seated (Kraus, 1991), continuously as a function of in-vehicle density (IVD) (Jara-Díaz and Gschwender, 2003), or both (de Palma et al., 2015). Density can thus be integrated in the analysis of optimal supply and pricing (De Borger and Wouters, 1998; Parry and Small, 2009; Wardman, 2014). Significant welfare costs of crowded PT are also found empirically using both survey data on stated preferences (SP) (Wardman and Whelan, 2011; Haywood and Koning, 2015) and revealed preferences (RP) (Batarce et al., 2015; Tirachini et al., 2016). The latter studies estimate the parameters of the utility function based on trade-offs between travel time, money and IVD. These are then used to calculate monetary value associated with comfort improvements, "willingness to pay" (WTP), or "time multipliers" which evaluate the cost of crowded travel conditions in terms of additional time (see Wardman and Whelan, 2011; Li and Hensher, 2011). With these valuations, in-vehicle crowding can be integrated as part of the generalized cost of PT, thus allowing an normative assessment of alternative policy choices (Batarce et al., 2016).[1]

Whilst higher IVD implies spatial limitation for individuals, it only generates economic consequences as an "experimental state" (see Stokols, 1972). Personal and trip characteristics may modify this experience, hence we take these into account in our analysis. Furthermore, this experience is intrinsically subjective.[2] Therefore it seems most relevant to use a subjective indicator to measure it. We use a self-reported satisfaction measure in this paper. Individuals are able to rate their well-being during long or short periods of time (Van Praag and Ferrer-i Carbonell, 2008). Metcalfe and Dolan (2012) conclude that reported satisfaction measure is a good measure of the underlying utility of a transport journey.

This paper focuses on comfort satisfaction (CS), allowing travel time to moderate CS alongside other trip and individual characteristics. The crowding effect is understood as the utility cost due to lack of in-vehicle space and may thus vary across PT users: apart from IVD, it may also depend on travel and individual characteristics. In this framework, we address two research questions:

1. How does IVD relate to subjective CS stated by users and what determines the subjective CS? We use data on individual self-reported measures of satisfaction (derived from a field survey conducted late 2010 on platforms of Paris subways). This data allows a direct assessment of the perception of crowding and its impact on the satisfaction of PT users is in line with the empirical literature on subjective well-being (Kahneman and Krueger, 2006) or job satisfaction (Clark and Senik, 2010). This study contrasts with previous studies in two aspects. Compared to RP or SP studies, we approximate the utility cost of higher crowding based on changes in stated CS, rather than through trade-offs with money or travel time. Our alternative approach and data allow us to identify a crowding effect dependent on user income but independent of travel time. We differ from studies (Eboli and Mazzulla, 2007; Cantwell et al., 2009; Dell'Olio et al., 2011) looking at overall PT satisfaction in that we focus specifically on the effect of crowding on PT satisfaction.
2. What explains the discomfort associated with crowding in PT? We investigate the reasons for low CS, defined as "causes of crowding discomfort" (CCD), i.e. *those features of a journey that are deteriorated by high passenger IVD*. In this study, we consider eight causes of discomfort, described in detail in Section 2.2. To our knowledge, we are the first to empirically test different candidate CCDs to understand the origins of the deterioration in CS. Having a better idea of the nuisances that really affect users can inform public policies. This study could thus highlight whether individuals will be better-off if they are offered additional seats, efficient cooling systems or more security in carriages.

The paper proceeds as follows. Section 2 presents the data and survey design. The Paris PT network constitutes a perfect case study to address in-vehicle crowding due to the recent growth in its patronage and no evidence of bottleneck effects. An active anti-car policy has been there implemented and succeeded to enhance a huge modal shift toward rail-based PT. Since PT supply could not adapt as fast as PT demand, however, IVD grew by 10% over 2000–2009 whilst service regularity remained unchanged, see Haywood and Koning (2015). Section 3 estimates the relationship between crowding (IVD), satisfaction with PT (CS) and other moderating factors. Section 4 uses original data to assess the most important reasons for this crowding effect.

2. Data

Our data was collected in the Parisian mass transit network in late 2010. Around 1000 users were interviewed directly on platforms of subway lines 1 and 4, during morning (7:30–10 am) and evening (5–7:30 pm) peaks, whilst waiting for their train to arrive.[3] Subway line 1 crosses Paris East-West. It is the busiest service of the subway network with 750,000 daily users

[1] Note that different studies make different assumptions about how the cost of crowding relates to travel time. Most empirical studies assume that the utility cost of crowding is proportional to the time spent in the crowded condition, interacting travel time and crowding in PT users' utility function (Whelan and Crockett, 2009; Tirachini et al., 2013; Haywood and Koning, 2015; Batarce et al., 2016 among others). Thus, the marginal utility of travel time varies with respect to in-vehicle crowding. Alternatives are a fixed crowding cost per trip (Kroes et al., 2013; de Lapparent and Koning, 2015) or both additively and in interaction with travel time (Li et al., 2016).

[2] Mohd Mahudin et al. (2012) distinguish three components of the experience of passenger crowding (evaluation of psychosocial aspects of the crowded situation, emotional reactions to the crowded situation and evaluation of the ambient environment of the crowded situation) to evaluate the relationship between crowding and stress and feelings of exhaustion.

[3] The stations where the survey has been conducted are, from East to West, *Gare de Lyon, Hôtel de Ville, Champs Elysées, Georges V, Argentine* and *Esplanade* for line 1, and, from South to North, *Denfert-Rochereau, Montparnasse-Bienvenüe, Saint Sulpice, Odéon* and *Les Halles* for line 4.