The marginal social cost of service reliability

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It is increasingly acknowledged that service reliability matters to transit users. First, service unreliability entails travel time variability, the consequences of which are now well documented for travelers (Bates et al., 2001; Carrion and Levinson, 2012; Fosgerau et al., 2008). Travel time variability may for instance induce anxiety or hinder the planning of activities, but its primary impact is generally the potential delay at destination (STRATEC and RAND Europe, 2004). Second, service unreliability also influences in-vehicle congestion. In the case of a bus service for instance, at a given station the queue of passengers waiting to board will grow when a bus is delayed, leading to greater in-vehicle congestion (Chen and Liu, 2011).

This paper intends to shed light on the impact of service reliability on in-vehicle congestion and the cost of travel for high frequency public transport services. We adapt the standard bottleneck model of road congestion with peak-load demand to the case of a headway-based transit service. Service unreliability is modelled through stochastic headways. This will allow us to explore the impact of a change in either the mean headway or the headway standard deviation on the departure rate, congestion, and the equilibrium trip cost. By doing so, we intend to give some insight into the influence of service frequency and service reliability on travel conditions for congested transit services.

This work is closely related to two strands of the literature on travel time variability. The first one studies the impact of travel time variability on congestion and the cost of travel in the case of car users (Coulombel and de Palma, 2014, 2013; Noland and Small, 1995). While this paper uses a similar
methodology, it takes into account various specificities of public transportation. First, transit services do not operate continuously, which constrains the arrival time and may entail waiting time for users. Second, transit users often value the waiting time and the in-vehicle travel time differently. As opposed to the case of car users, this means that we cannot consider the total travel time and must distinguish between waiting time and in-vehicle travel time. Last, road congestion is a continuous phenomenon, while in-vehicle congestion may strongly vary between two successive vehicles. This is especially true in the case of bunching (Chen and Liu, 2011).

This work also relates to another strand of the literature, which studies the value of service characteristics. The marginal social cost of headway is derived in Fosgerau (2009) in the case of a scheduled service. Benezech and Coulombel (2013) derive the value of service reliability in the case of headway-based transit services. The present paper extends their work by considering the link between service reliability and congestion, which was only crudely done in their paper. As noted above, this point is important for heavily congested transit services, for which service unreliability is likely to be even more costly due to its impact on in-vehicle congestion.

References