Summary:

In-vehicle crowding: An overview with suggestions for future work

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Author: Harald Minken
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In-vehicle crowding in public transport systems may call for high rush-hour fares and other forms of demand management, not only on the road, but also in the public transport system. The existence of crowding increases the economic value of capacity expansion, but on the other hand, it also implies that it is no longer obvious that day-to-day operations of the urban public transport system should be heavily subsidised. Thus in the light of increasing crowding and congestion in the public transport system, a nearly fifty year old truth in transport economics will have to be revised, wholly or in part.

To take account of in-vehicle crowding in cost benefit analyses requires a major revision of the part of the urban transport models that concerns public transport route choice. There is more than one way to do it, but no way yet of including all important effects and distinctions in only one model. Provisionally, one will have to make do with some simpler computations outside of the models.

Lately, in-vehicle crowding in the public transport system is about to become a serious problem in and around the major cities of Norway. In-vehicle crowding is a form of external effect that the public transport users impose on each other. In about the same way as when cars on the road impose congestion costs on each other, passengers impose crowding costs and other inconveniences and disutilities on each other on local trains, metros, buses and trams. Having to stand and not being able to get a seat is an inconvenience, and it gets worse the closer people have to stand together and the longer it lasts. This is explained in Chapter 2. Crowding also leads to boarding and alighting taking longer time, and thus to more time being used at stops. This is an external cost imposed by those boarding and alighting on those on board, increasing their travel time, and on the public transport operator, increasing the need for rolling stock. Eventually, it may also lead to reduced punctuality and other forms of disturbances. Ultimately, the vehicle may get so crowded that it cannot allow new passengers to board.

Valuation studies have quantified the mean crowding costs that individuals experience at different levels of crowding. This is the basis for economic appraisal of the costs to society of crowding. But for a proper appraisal, it is not enough, because it does not take into account how the passengers react to changes in the level of crowding. For instance, they may react by reducing the number of trips, by shifting mode, by travelling at other times of day or by choosing other public transport routes. To take a somewhat extreme example: In some cities of the world, it is observed that travellers begin their trip by travelling in the opposite direction of where they are ultimately headed. This is because that way, they are able to get a seat. They keep their seat until the end of the line, and thus they are able to keep their seat also when the train turns around and heads in the right direction. The price they pay is the extra time that their trip takes.

So called transport models are used to predict how travellers react to changes in the transport system. They are a form of demand functions that compute probable trip frequencies, destinations, modes and route choices at the level of the individual, based on zone of residence, car ownership rate and other characteristics of the individual, and trip times, out-of-pocket costs and other relevant characteristics of the transport system. The Norwegian urban transport models have by and by been able to give a fairly good representation of congestion in the road system, making travel time on a given segment of roads and streets depend on the level of traffic there at a given time of day. But we lack something similar on the public transport side. This is because The sub model that predicts the choice of route through the public transport system does not take account of the level of crowding on the different lines and modes. The purpose of the present report is to point out ways to overcome this deficiency, both in the short run (by computations outside of the transport model system) and in the long run (in the form of a new sub model for public transport route choice in the urban transport models).

The literature on in-vehicle crowding has now become fairly large. This includes the literature on models and algorithms to find user equilibrium in congested and crowded networks of realistic size. To help with the tasks ahead, the present report provides a fairly large list of references, and in Chapter 3 we briefly survey this literature. In addition, many of the articles that we refer to have their own comprehensive literature reviews, with many entries that we have not included here. It is hoped that Norwegian transport research will be able to able to find resources to go deeper into this literature in the coming years.

In the short run, we recommend either to use elasticities to adjust down demand on trip relations with crowding, or to leave it to the transport model to make the adjustment by increasing the perceived time cost or trip time in the generalised costs on selected trip relations of the model system.

Elasticity computations are treated in Chapter 4.

A more sophisticated method of adjusting demand is to adjust the generalised costs in the model. The generalised cost on a trip relation is the sum of time costs, monetary costs and other cost components that determine demand on this relation. It is important that the adjustment of trip times and costs only affect passenger demand, not the costs of the public transport company. Therefore one must keep the real link transport times when the costs of the public transport company are computed. Alternatively (or in addition) one might add a constant to the generalised costs of public transport trips on particular trip relations. Both methods have been tested in Bel, Pel and Pieters (2014).

Of course, all such adjustments must have a sound empirical basis. For a start, one might use the figures of Figure 1 in the report. They are a subjective assessment of how the value of time increases with the level of crowding in some of the newest and best international value-of-time studies. But of course the results of using these values must be compared with observed traffic at different levels of crowding.

What we do not take into account by this approach is that those who get a seat and those who will have to stand experience the in-vehicle congestion differently. If we think this is the most important aspect of this form of congestion, a range of models are available, from simple analytical models of single lines to large-scale assignment models, potentially covering public transport networks of very large cities. The data for such models may partly be taken from valuation studies and partly from counts of boarding and alighting movements and ridership on all lines. To take due account of the difference between those who sit and those who stand, however, one will have to ignore how the perceived congestion costs increase with the level of congestion. One cannot have it both ways.

Peculiarities of the scheduled supply in the metro system of Oslo at the moment makes it possible to estimate crowding costs by the so called revealed preference method. A proposal for such a study is outlined in Chapter 5.

A precondition for both the short and long run work is that good and reliable data on boarding and alighting at stops and stations, and on the number of passengers on board on all links between the stops, exist or can be established. The data should probably be an average over the hour with the highest level of demand.

In all probability, we will have to live with crowding in the public transport system of the largest cities for at least 10 to 15 years (and maybe forever). In the meantime, there will nevertheless be a variety of minor projects and inexpensive policies that can reduce the problems. In Chapter 6 we mention some of these. Just like road pricing on the road, it may be efficient to increase fares in public transport in the period when the crowding problems are at their worst. Alternatively, one might offer cheaper tickets (or perhaps free tickets) for an hour or two before the rush hours. One might also share the burdens of crowding more equally between all young and able-bodied passengers, by reducing the number of seats and improving conditions for the standing. It seems probable that as time goes by, public transport users in Norwegian cities will gradually adapt to more crowded conditions, in the same way that the public transport users in large cities in other countries have done. But for this to happen, a cultural change must occur, and that will not always come of itself.