第Ⅳ部門 Public Transportation Fare Level and Structure Optimization in Model Cities

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Introduction:

With recent advanced payment systems, more differentiations in fares are made available, leading to the question: How detailed should a fare structure be? In particular, are distance-differentiated fares good from a social welfare perspective? To figure out the answer as the perspective of urban planner, as well as to comprehend better how fare levels and spatial structures would influence passengers' modal choices and PT service quality, we propose to include fare and demand elasticity in a model proposed by Daganzo (2010).

Methodology:

Daganzo proposed a model where cities and their public transport network are simplified so as to obtain some general insights. The public transport network is described as a hybrid network, composed of a grid network service in the city center and a hub and spoke network in the periphery. The model determines the optimal ratio of central dense PT service area ratio (α), stop spacing (s) and network headway (H). The goal is to obtain the case that minimizes the overall social disutility, considering as input city size, average speed of service and total demand density. Here we add the fare term into the model and consider the demand density as an elastic variable that is a function of the sum of users' disutility and fare. We assume that when fare is high more people would choose to utilize an alternative mode, which is proposed as taxi here. We apply two of the main spatial fare structures, flat fare and zonal fare, to understand their effects on total social disutility. For zonal fare, we divide trips into three groups, those across the center and periphery boarder, those within the center and those within the periphery, denoted as CP, CC and PP respectively, in ascending order in charge. We note that there is some similarity to the fare structure in Kyoto. Both of the fares are applied to different scenarios following largely case studies in Daganzo (2010). Firstly, a base scenario, resembling Barcelona; then a city with high PT demand;

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a sprawl city scenario, resembling most cities in the US; and a big city scenario, resembling Paris. We additionally construct a small town scenario and a Kyoto-type city scenario.

Results:

As fare levels increase, first the public transport demand remains nearly constant, and the service quality improves since stop spacing s and headway H decrease, while α decreases only slightly. This leads to an increase in the operators' disutility and a decrease in users' disutility, while the total disutility does not change. At higher fare there is an inflection point for every parameter, which is due to the start of demand decrease: s and H gradually increase though α does as well. Therefore the users' disutility increases but the operators' as well due to reduced demand. Generally with this we can conclude that for a mild fare increase, the users pay more fare, but get correspondingly improved service, while when the fare gets too high, they would choose to utilize the alternative mode which provides significantly better service. This leads to a demand decline, a worse service and increased disutility. The inflection point depends on both city size and demand density though a general conclusion is difficult to obtain with current results. Secondly, we analyse the fare over operators' disutility, to understand how much of the operating costs can be covered by the fare revenue. We find that there is a peak which indicates the maximum coverage of cost, which occurs for fairly low fare when demand for PT is still high. This maximum ratio varies through significantly between the city scenarios depending to a large degree on the demand density. Thirdly, we find that in flat fare scenarios, the optimal fare always converges to the minimum feasible fare, while in zonal fares, there exists an optimum fare, due to the complex relationship between demand splits. However, this fare differentiation was not significant except for the small town scenario, where α is high and s is small. Here the fare of CP trips is high, while CC and PP are similar and small.

Conclusions and Implications:

From a social welfare perspective where operator and user costs are weighted equally we find evidence that for most city types there is not much reason to increase fare. Having said this, we can identify a higher fare that maximises the ratio between operator costs and expenses while demand for public transport is not likely to be much affected at such a fare level. Possibly contrary to expectations we find further that zonal fares are potentially useful in smaller towns since here the overall disutility for passengers is lower due to shorter trips. The additional revenue from the zonal fare can then help to maintain a good grid-network type service for a large area even for a relatively small town.