A meta-study on the significance of rail networks on public transport ridership

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1 Introduction

Attractive public transport systems are increasingly important in ensuring mobility in the increasignly congested metropolitan areas. Such systems require a focus on high service levels including high accessibility to be able to compete with other modes (e.g. [1], [2], [3]). Many citites therefore invest in rail-based systems which ensure a high level of service with regards to travel time, reliability and comfort as well as large capacity. The costs for such systems are much higher than bus-based counterparts, thus making it necessary to ensure that money are spent on the most efficient system.

An overview of the attractiveness of public transport systems can be developed by analysing the ridership across multiple cities. Several previous studies have analysed which factors generally influence ridership (e.g. [3], [4], [5]). However, most studies lack general results that can be used in an European context, e.g. only relying on few cities (e.g [5]), and not taking into account the difference between public transport modes (e.g. [3]).

This paper analyses at a meta-level the public transport ridership across approximately 50 European cities. The analysis distinguish between ridership across public transport modes in order to analyse the effects of modal networks. Connectivity within the public transport network is analysed by taking into account the network topology. The results are discussed in relation to the choice of system which cities faces when developing their public transport network.

2 Background

Public transport ridership can in general be explained by a general model approach that relates demand and supply of goods, e.g. based on [6]. The demand model should take into account (i) characteristics of the travellers, (ii) the characteristics of the metropolitan area (physical and economical), (iii) the availability of substitute modes, and (iv) the (generalised) costs of the public transport mode, as suggested in [3]. Creating such a model is difficult when supply and demand are highly dependent which is the case for public transport as the extent and frequency of service heavily influence the ridership. Most existing literature is based on multivariate regression models.

Many studies have analysed the factors creating an attractive public transport network. Generally, travellers want to minimise their generalised travel costs which on a micro scale corresponds to choosing the alternative that has a high level of service. This primarily includes high travel speeds,

high frequency, high level of comfort, and low fares [2]. Most aggregate studies finds that service levels are more important than fare levels in describing transit ridership, e.g. [3].

An important overlooked parameter in previous analyses on ridership is network connectivity. A dense network will make it possible for users to travel to more destinations with smaller access and egress times. Hence, a highly dense network makes it possible for the users to use public transport for all their trips as they have more travel options. This makes it easier for users to navigate from origin to destination, and in times of disruptions gives users possibility of changing their route. Several previous studies on connectivity of public transport networks rely on detailed representations of the network structure ([7], [8]) and/or spatial layout ([9]). These studies require the use of advanced traffic models with specific arcs for transfers and actual timetables for the public transport network. The analysis in this paper implements connectivity in the model based on spatial layout by using network topology. By this it will be possible to take into account the ease of transfers in the public transport system.

3 Data and approach

The aim of this paper is thus to analyse public transport ridership in metropolitan areas around Europe. The overall goal is to estimate the significance of rail-based public transport systems on the overall ridership and modal shares of European cities. Statistical regression models are applied on ridership while controlling for a large number of background variables. The study builds upon previous studies, e.g. [3].

The paper will investigate several hypotheses concerning rail-based public transport ridership including the existence of the so-called rail-factor ([10],[11]). By analysing the ridership in cities across different networks it will be possible to estimate the significance of dense public transport networks. This will include analysing the effects of light rail systems which is being implemented throughout Europe, as compared to metro systems and urban rail systems.

Finally, the connectivity of the public transport systems will be analysed. In this analysis aggregate measures will be formulated which takes into account the topology of the network.

Data for the study consists of ridership data separated into public transport modes (suburban rail, metro, light rail, and bus) for approximately 50 European cities. Data is collected by the author from a varity of sources including UITP[1], Passagerpulsen[2], and from official public transport agencies across Europe. The analysis is delimited to European metropolitan areas with a population of at least one million people.

[1] UITP is the International Association of Public Transport which collects statistics on the public transport systems around the world. For this study their database on metro data has been used.

[2] *Passagerpulsen* is a project group with the purpose of improving the public transport system of Copenhagen by e.g. collecting various data for the public transport systems around Europe.

4 Results

This paper presents estimates on the significance of coherent and dense public transport networks in metropolitan areas. Ridership in a large number of European cities will be explained by the network characteristics including especially the coherence and connectivity of the network.

The results of multiple models will be compared in order to estimate the significance of different rail-based public transport systems as well as bus-based networks on the ridership.

The paper first describes the data at hand, then the model estimations including the modelling approach and goodness of fit, and finally a (number of) fully reduced model(s) with the purpose of explaining ridership in public networks in metropolitan areas by a number of variables relating to the level of service, price of fares, and network characteristics with the goal of estimating the significance of establishing a network as compared to single lines.

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