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Modelling the potential effect of shared bicycles on public transport travel times in Greater Helsinki: An open data approach☆

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A B S T R A C T

In many European cities, support for public transport and cycling in daily mobility is considered an efficient means to reduce air pollution, traffic jams, and carbon emissions. Shared bicycle systems have turned out effective in increasing cycling in many urban areas, particularly when combined with public transportation. In this study, we make an effort to model a hypothetical shared bike system and quantify its spatial effect on public transport travel times. The study area is one of the fastest growing urban agglomerations in Europe, the Greater Helsinki area in Finland. We model the travel times between the population and 16 important destinations in the city centre of Helsinki by public transportation and by public transportation extended with shared bikes. We use open route and timetable databases and tools developed in-house to perform extensive data mining through application programming interfaces (APIs). We show 1) that open transport information interfaces can provide a new effective means to evaluate multimodal accessibility patterns in urban areas and 2) that the launch of a bicycle sharing system could reduce public transportation travel times in the study area on average by more than 10%, meaning some 6 min per each individual trip. We conclude that bicycle sharing systems complementing the traditional public transport system could potentially increase the competitiveness and attractiveness of sustainable modes of urban transport and thus help cities to promote sustainable daily mobility. Finally, we emphasize that the availability of open data sources on urban transport information – such as the public transport data in our case – is vital for analysis of multimodal urban mobility patterns.

Introduction

With growing urban population and increasing daily traffic, the development of more sustainable urban transportation systems is crucial in many cities around the world (Pucher, Garrard, & Greaves, 2010; Tight et al., 2011). Public transportation and cycling are increasingly promoted to mitigate traffic-related problems such as traffic jams, pollution, expensive road infrastructure, accidents and congestion. In comparison to private cars, cycling is considered a quiet, fast, healthy, emissions free, equal and space-efficient means of transport (Andersen, Schnohr, & Schroll, 2000; Chapman, 2007; Dekoster & Schollaert, 1999; Jensen, Rouquier, Ovtracht, & Robardet, 2010; Pucher, Komanoff, & Schimek, 1999; Tolley, 1996).

Consequently, many cities and public authorities have created strategies to increase cycling and are investing in bicycle lanes, shared bicycles or 'bike and ride' schemes (Lumsdon & Tolley, 2001; Martens, 2007; Midgley, 2009; Pucher et al., 2010). On the other hand, studies (Goetzke & Rave, 2011; Keijer & Rietveld, 2000; Müller, Tscharaktschiew, & Haase, 2008; Pucher & Buehler, 2006; Rietveld & Daniel, 2004) have shown that cycling may not be an appealing option if distances grow, particularly in areas with varying weather or hilly topography. Krizek and Stonebraker (2010) have identified factors affecting bicycle use in the travel chain. In summary, people are more likely to use cycling transit in suburbs than in the city centre and fast long distance transit seems to draw more cycling transit users. Short egress distances usually mean more cycling transit users, most likely on trips to work or school.

Martens (2007), Pucher et al. (2010) and Krizek and Stonebraker (2010) propose that efficiently integrating bicycling into public

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transport could increase the share of sustainable means of transport. This is interesting because, according to Martens (2004), bicycles and public transport have traditionally been seen as competitors and their synergy possibilities have largely been ignored. Perhaps consequently, integrating bicycle and public transport in the activity end is seldom seamless or flexible. In some countries, bicycles are nevertheless widely used to access public transport stations (Keijer & Rietveld, 2000), but the share is substantially smaller on the egress part of the trip due to the limited availability of bicycles (Keijer & Rietveld, 2000; Martens, 2004). Modern bicycle sharing schemes have the potential to overcome some major shortcomings of integrating bicycle and public transportation. Shared bicycles (also known as public bicycles or smart bikes) are bikes that are generally available for loan, usually for a small deposit. In its most popular form, bicycles are checked out and returned to unattended stations located throughout the city. This system enables citizens to use bicycles on a flexible "as needed" basis (Shaheen, Guzman, & Zhang, 2010). After the launch of the first extensive modern bicycle sharing system (BSS) in Lyon in 2005 (DeMaio, 2009), the number of cities implementing such schemes has grown rapidly (Midgley, 2011) despite challenges, foremost the imbalances in supply and demand of bicycles. One of the main goals of BSSs have been to enhance accessibility by public transport and to improve the competitiveness of sustainable means of transport by integrating bicycles into urban transportation systems (Lin & Yang, 2011; Midgley, 2009; Shaheen et al., 2010). The first results suggest that these goals might be attainable, as shared bike trips have replaced car trips (Bührmann, 2007; Nadal, 2008), and the share of trips by bicycle has increased (Bührmann, 2007).

Due to the relatively short history of modern BSS, research on such systems and their impacts is still quite scarce, although growing rapidly. Most BSS studies have focused mainly on identifying spatiotemporal trends from the station hire data (Borgnat et al., 2011; Froehlich, Neumann, & Oliver, 2009; Kaltenbrunner, Meza, Grivolla, Codina, & Banchs, 2010) or on optimizing BSS station locations and the number of bikes (García-Palomares, Gutiérrez, & Latorre, 2012; Lin & Yang, 2011; Lin, Yang, & Chang, 2011; Sayarshad, Tavassoli, & Zhao, 2012; Vogel, Greiser, & Mattfeld, 2011). Studies assessing BSSs as a part of the public transport system from spatial viewpoint are, however, scarcer (see, however, Anaya & Bea, 2009; Bührmann, 2007; Nadal, 2008).

Enhancing accessibility by sustainable means of transport is one of the key aims of BSSs. For long, reliable GIS analyses of multimodal trips have been too data hungry and computationally intensive to calculate over large extents. During the past years, the situation has changed remarkably as public administration, NGO's and private companies are opening network datasets and/or programming interfaces that allow batch routing along road and public transportation networks (Lei & Church 2010; Martin, Jordan, & Roderick, 2008). In Europe, this development is partially resulting from the PSI and INSPIRE directives, open data activism and, importantly, cities' competition on innovative entrepreneurship (Bakici, Almirall, & Wareham, 2013; Hielkema & Hongisto, 2013). The availability of standardized data formats (e.g. the General Transit Feed Specification) and increased computing capacity (e.g. cloud computing) are making intensive multimodal transport analyses feasible for a larger group of researchers and practitioners (Yang, Raskin, Goodchild, & Gahegan, 2010). Different fields of science are reacting on this development on a different phase: whilst the use of open data and related discussions is already commonplace, for example, among biological sciences (e.g. Molloy, 2011; Reichman, Jones, & Schildhauer, 2011), the potential of open data is yet to be fully discovered among urban studies.

In this paper, we use openly available data sources and routing interface to quantify the potential impact of a bicycle sharing system on public transport travel times and to analyse the formation of the BSS's spatial pattern. Greater Helsinki (the capital region of Finland) provides an ideal test case for such an analysis: there are plans to implement a modern BSS in the region, public transport route and timetable databases as well as spatially referenced population statistics are openly available for everyone via a query interface (Journey Planner, 2012) and regional data service (http://www.hri.fi/en/). Our specific study questions are:

1) Would a bicycle sharing system influence public transportation travel times? If so, how much and in what kind of areas in the city structure? Where would be the busiest bike hubs be located?
2) Could such questions be answered with freely available data sources and routing interfaces, mainly planned for public transport users?

In practice, we compare travel times and travel routes between inhabited 250-m $\times$ 250-m grid squares ($n = 6906$) in Greater Helsinki and 16 important points of interest (POIs) in the Helsinki city centre using 1) public transportation (PT) alone, 2) bicycles alone, and 3) a combination of the two (PT + BSS).

Data and methods

Study area

Our study area Greater Helsinki is the largest urban agglomeration in Finland both economically and in number of inhabitants (ca. 1 million) (Fig. 1). Compared to many European cities of similar size, the urban fabric (particularly population) of Greater Helsinki is relatively scattered (European Environment Agency, 2006). After the 1950s, the capital region experienced a structural change in the form of suburbanization (Vaattovaara, 2011) but despite the growth of sub-centres, the Helsinki city centre remains by far the strongest centre in the region (Vasanen, 2012) with highest population and job densities.

In comparison to other European cities, residents are satisfied with the public transportation system (European Commission, 2010), which consists of a metro line covering the eastern suburbs, three commuter railway lines to the north, northwest and west of the city, a tram network of 12 lines in the extended city centre, a ferry line, and an extensive bus network (Fig. 1). Despite the good public transport connections, the city is experiencing increasing traffic by private cars, more traffic jams and parking problems.

The city aims to increase the share of cyclists from 9% to 15% by the year 2020, despite the challenges of Helsinki's northerly weather conditions (the city can experience on average 3 full months of snow cover during the winter months). In the past decade, the city has established a number of new bicycle lanes in the city centre and dedicated bicycle pockets in front of traffic lights. Special emphasis has been put to the winter maintenance of bicycle lanes. The mid-2000s saw a small scale bicycle sharing system operating in the Helsinki city centre. To become a part of citizens' daily mobility the system was, however, too small, using old technology (coin deposit) and the bicycles were poor (Helsinki City Transport, 2008). Now there are plans to launch a modern and considerably larger BSS.

Data

In our analyses, we used different data sources, as specified in Fig. 2. Firstly, data on population by buildings from the year 2010 (Helsinki Region Environmental Service Authority, 2011) was aggregated to 250-m grid squares. This served to identify the