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Do buses hinder cyclists or is it the other way around? Optimal bus fares, bus stops and cycling tolls

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ABSTRACT

This paper optimises the number of bus stops, and prices for car, bus and cycling in the busiest inner city corridor in Stockholm. We adopt the representative consumer approach and calibrate the current equilibrium using the quasi-linear utility function. We find that the number of bus stops is already close to optimal. Welfare would increase if the peak frequency was increased, if the bus fares were lowered and differentiated between long trips and short trips and, and that the toll for longer car trips was increased. The optimal toll for cyclists, and the welfare benefit from it, is small and does not compensate the transaction costs. The distributional effects of bus fare changes and higher car tolls are small because on one hand, high income groups place more value on travel time gains, but on the other hand, low income groups travel less frequently by car. Surprisingly, we find that in the welfare optimum, the bus service only requires a small subsidy due to congestion in the bus lane, crowding in the buses, and extra boarding and alighting time per passenger. The Mohring effect is limited because the demand, and thereby the baseline frequency, is already high.

1. Introduction

It appears that cycling has received increasing attention from planners and decision makers in the US and Europe in the past decades (CEMT, 2005). The EU commission's Green Paper (European Commission, 2007) states that "More attention should be paid to the development of adequate [bicycle] infrastructure". Since the 1990s, cycling has also been increasing in inner cities in America, Canada and Australia (Pucher and Buehler, 2012). In Stockholm, Copenhagen (City of Copenhagen, 2011), London (Transport for London, 2015) and various Dutch cities (Ministry of Transport Netherlands, 2009), cycling is increasing in the dense city core (but not further out in the counties). This increases the interaction between cyclists and other transport modes. Still, the large literature on optimal welfare pricing and allocation of road lanes (Basso and Silva, 2014; Parry and Small, 2009) has so far neglected cycling.

In this paper, we extend previous analysis on welfare optimal pricing and public transport design to include cycling. There is a case for pricing cyclists if cycling gives rise to substantial congestion. However, if the other modes (often cars) are under-priced (no tolls) cycling tolls might not be justified because that would divert too many cyclists to these other under-priced modes. This is why it is so important to analyse all modes simultaneously. The interaction between cyclists and other transport modes depends on the street design around the bus stops. In many cities the bicycle lane often disappears at the bus stop, forcing cyclists to divert into the car lane. Typically, cyclists either have to wait for the bus to leave the bus stop, or overtake it by diverting into the car lane, which in turn

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slows the cars down.

In the seminal work by Mohring (1972), the optimal number of bus stops is a trade-off between access cost on one hand, and in-vehicle travel time and operation costs on the other. In our model we add a much less studied second element which influences the optimal number of bus stops: the interaction between buses and other traffic at the bus stop including cyclists. We focus on the efficiency aspects assuming full control of the supply side by the planner and leave the procurement dimension of bus supply aside. We define a formal model, linking demand and supply, for an inner city corridor and calibrate the model for Stockholm. The model takes into account the interaction between different modes, this allows to model the effect of different policy instruments. We derive the optimal pricing of cars, buses and cyclists in the corridor. The optimal pricing of cyclists depends on the extent to which they create congestion in the street in a direct way, and to what extent they slow down other modes at the bus stop. If use of buses and cars is not priced correctly, the pricing and investments for cyclists should also take into account the possible substitution effects. The model also optimises bus frequency and number of bus stops. Finally, we also explore how the optimal number of bus stops, prices and frequencies depend on the design of the bus stops.

Given the political goal to increase cycling in many cities, it may be odd to launch a toll for cyclists. The increased promotion by policy makers is not at all surprising, given the advantage of bicycling in dense cities – its space efficiency when used and parked, low travel time, reliability, low cost, quietness, and cleanness. What is surprising, however, is that cycling is rarely seen as one travel mode among others, with its merits and demerits; it is usually motivated by its indirect effects: zero emissions and health benefits. By exploring a toll for cyclists, we acknowledge that cycling also gives rise to congestion.

The correlation between cycling and health is well established, and for this reason, some authors have claimed that health benefits add major external benefits of cycle investments (Sælensminde, 2004; Krag, 2005; WHO, 2011). Health benefits include the value assigned to human helath, injuries, and deaths, but also the costs for the social security system and production losses. However, the human value of health, injuries, and deaths constitutes 75–85% of the total health benefits of cycling (Swedish Environmental Protection Agency, 2005).

Now, the traditional view in economics literature is that personal health is primarily an individual responsibility and benefit (except the cost for the social security system and the external part of the production losses), and thereby internalised in the travelers' choice to cycle. This standpoint in the economics literature is based on the fundamental principle of "consumer sovereignty". This standpoint has of course been challenged, for example by the literature on "sin taxes", diverting from the "consumer sovereignty" principle based on the assumption that consumers not have full information or self-control, and therefore not act according to their own best self-interest. However, even if there is only a tiny literature on internalization of health benefits for cyclist, the existing evidence supports that health benefits are to a large extent internalised in travellers' decisions and that cyclist replace to a large extent other exercise with cycling (Börjesson and Eliasson, 2012b). For this reason, we assume in this paper that the health benefits are internal: the awareness of health benefits increases cycling volumes, reducing the values of time for cyclists and is thus already considered in our analysis. Apart from external health benefits of cycling, we also view accident risks of cycling as being internalised by cyclists. We realize that this is controversial, but there is on the other hand no evidence that health benefits and accident risks of cycling are not largely internalised, i.e. that travellers do not act according their self-interest.

The assumption that buses are more intensively used by lower income groups is often used as an argument in favour of reducing bus fares. Moreover, the view that low-income groups cycle more, is widespread. This used to be the case for Stockholm but is no longer true (Börjesson and Eliasson, 2012a). In the Netherlands, Germany, Denmark and in many more European cities cycling is or is becoming a mode used by all income groups (Pucher and Buehler, 2008a, 2008b; Vedel et al., 2017). For this reason, we also explore the income redistribution of the policy instruments under study.

Stockholm differs from most other cities in that congestion charges are levied on the corridors leading into the city. Due to the extensive monitoring program that was put in place when the charges were first introduced in 2006, data regarding traffic flows, elasticities and cross-elasticities are also well documented in Stockholm.

The paper is organised as follows. Section 2 briefly discusses the literature. Section 3 presents the model components. Section 4 derives optimal pricing, frequency and optimal bus stop rules. Section 5 presents the study area and the calibration data. Section 6 presents numerical results and Section 7 documents the sensitivity analyses. Section 8 generalizes our results and Section 9 concludes with some caveats.

2. Literature and contribution

There are two strands of research that are useful for our purpose. There is the general theory on public transport pricing and organisation, and there is the specific research on bus services, including the number of stops.

Optimal pricing and frequency principles for public transport have been developed by Mohring (1972) as well as Jansson (1980, 1984), Viton (1980), Kraus (1991), Jara-Díaz and Gschwender (2003b), Monchambert and de Palma (2014), de Palma et al. (2015) and De Borger and Proost (2015). The optimal pricing and frequency rules have been illustrated for metropolitan areas by Parry and Small (2009), Basso and Silva (2014), Kilani et al. (2014) and Tirachini et al. (2014b). The principles put forward are that (i) for given frequencies, first best prices for bus use should internalise the external crowding costs and (ii) first best frequencies need to balance the costs of an extra bus with the decrease in waiting time costs (Mohring, 1972) and decreased crowding costs (de Palma et al., 2015) for the users as well as the increased congestion in the bus lane.

In his seminal work, Mohring (1972) explicitly models the optimal number of bus stops as a trade-off between the operators' costs and in-vehicle travel time versus access time. Jansson (1980, 1984) simplifies this model by assuming that the number of bus stops is constant, implying that it does not influence access time. On the other hand, Jansson considers peak and off-peak periods, and the