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Effects of upgrading to cycle highways - An analysis of demand induction, use patterns and satisfaction before and after

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ABSTRACT

Objective: The objective of the present study is to investigate the effects of improvements made to two large, interconnected bicycle infrastructure in the western suburbs of Copenhagen, Denmark, on bicycle volumes and mode share, and cyclists' behaviour, perceptions, and experiences.
Methods: Effects are assessed by analysing data from automatic counting stations during 35 months to measure the changes in bicycle volumes on the investigated routes. Furthermore, a questionnaire survey repeated three times – before, and one and two years after opening the improved routes - is used. Findings are supported by a control survey at a nearby facility, which was not influenced by the infrastructure improvements.
Results: The investments related to the two investigated cases of infrastructure improvements resulted in a significant increase in the volume of bicyclist two years after the improvements. On one of the routes, the "Albertslund Route", on weekdays during the rush hour in daylight, an increase from 126 to 203 bicyclists/h was recorded, whereas an increase from 24 to 32 bicyclists/h was recorded at "Vestvolden" for the same period. Most of the increase could be attributed to relocation of bicyclists from other routes. Induced cycling trips – trips that were not previously made by bicycle - were estimated to account for only 4–5% of the bicyclists two years after improvements. Bicyclists using the improved route express an increase in satisfaction with the quality of the facilities, which is significantly higher than at the control site.
Conclusion: Data from the counting stations provides useful information if measured over a long period. This is necessary to correct for factors such as climate effects and temporal variation. Investments in cycle infrastructure in the investigated case led to a higher number of bicyclists who were mainly relocated from other routes. A minor increase in the modal share of cyclists was observed two years after the infrastructure improvements. Furthermore, the investments resulted in a higher degree of satisfaction among active bicyclists. If measured over a longer period, this could lead to a higher modal share due to a potential social advertising effect.

1. Introduction

The promotion of cycling has gained increased political attention as an alternative to commuting by car both to avoid congestion because of environmental concerns and to increase individuals' physical activity and thereby health (see, for instance, Krizek et al., 2009; Ogilvie et al., 2011). Policy initiatives that aim to increase the modal share of bicyclists through improved urban design/infrastructure have been implemented in many cities around the world (see, for instance, Dextre et al., 2013) – both in smaller towns and cities (Handy et al., 2012) and in megacities (Pucher et al., 2012). Improvements to bicycle infrastructure are regarded as the main instrument to achieve such a goal (Parkin and Koorey, 2012). However, the crucial policy question is how good an instrument it is. This leads one to question which behavioural changes may result, and how they should be measured. This paper addresses this question based on *ex ante* and *ex post* user surveys and detailed longitudinal analysis of flows on a cycle highway and a cycle greenway project in Copenhagen in Denmark.

Following SACTRA (1994) and Hills (1996), increasing infrastructure capacity or improving its quality may influence the total volume of activities, their location and timing, the mode of transport used, coordination of activities by different individuals as well as the route

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chosen. More recent studies have addressed specific challenges when assessing investments in bicycle and pedestrian infrastructure (Krizek et al., 2009; Forsyth and Krizek, 2009; Goodman et al., 2013; Ogilvie et al., 2011). The promotion of cycling through investments may include the construction of new facilities, improvements to existing bicycle facilities and also advertising and educational campaigns. Parkin and Koorey (2012) argue that to support potential success, strategies and design should address whole networks or neighbourhoods rather than individual delinked elements of the infrastructure.

Hills (1996) – extending the work presented by SACTRA (1994) - defines trips that would not have been made prior to a given improvement as induced trips. Narrowing this down to address cycling, *induced cycling* can be defined as cycling trips that would not previously have been made by bicycle. Hills (1996) further distinguishes between rather short-term situations where the destination of trips made remains the same as before the improvement, and more long-term situations where new destinations are incorporated by the road users (changing jobs, location of shopping, etc.). The latter is also called second order effects (see also Ogilvie et al., 2011).

The studies addressed by SACTRA (1994) and Hills (1996) focus on car-based infrastructure where the main aim is often to reduce congestion. The investment in bicycle infrastructure targets several additional environmental and health benefit objectives. Accordingly, these goals can only be achieved when induced cycling appears, i.e. increased cycling frequency of already active bicyclists or when citizens change transport mode. If all new bicyclists on an infrastructure are transferred from other routes and no behavioural shift of present bicyclists takes place, no effects on emission, traffic congestion or public health can be anticipated (Ogilvie et al., 2011; Goodman et al., 2013; Krizek et al., 2009). As a consequence, a simple assessment of the change in cycle loads, for instance by means of automatic counting stations, will be insufficient; it needs to be qualified. One source of information for such qualification is questionnaire surveys (Krizek et al., 2009).

One reason to improve bicycle infrastructure that is often neglected during assessment is the well-being of the bicyclists. Improving the well-being of bicyclists may serve as an advert that targets non-cyclists, which may lead to a mode shift through social feedback (Ogilvie et al., 2011). In regions with a high mode share of bicycle transport, achieving a further increase in mode share can be challenging. In such regions, planning to enhance the well-being of bicyclists may be conducted in parallel with planning to increase the mode share of bicycles as this may be a goal in itself. This study is limited to addresses measures of cyclists well-being in relation to the improvements of the studied infrastructures (mainly surfacing and streetlight).

For many larger investments in bicycle infrastructure, quantification of the effects is a specific focus. In a Danish context, 'Odense Cykelby' (Troelsen et al., 2004) was a comprehensive improvement project for the entire city of Odense, the third largest city in Denmark. The effects were evaluated for the entire city by a cross sectional study based on telephone interviews. The most significant result was that the cycle mode share increased by 20% as a consequence of the improvements.

In the United Kingdom, an independent multidisciplinary collaboration called iConnect (2014) aimed to establish a theoretical basis for assessing the societal effect of improvement projects to build or improve walking and cycling routes at 79 locations around the country framed by the national project Connect2 (Ogilvie et al., 2011). The assessment, which had a special focus on health benefits, was conducted as a cohort research design, which recruited citizens living closer than 5 km to the improvement sites. In the evaluation of three sites reported by Goodman et al. (2013), respondents filled in a questionnaire before the improvements, and again after one and two years. One of the many conclusions reached was the level of use of new infrastructure was higher after two years than the first year after construction, and that the main predictor of using the new facilities was respondents' prior level of walking and cycling activity (Goodman et al., 2013).

Similar studies of effects of infrastructure improvements have been conducted both with a focus on the inhabitants of the case area (Keall et al., 2015) and by directly addressing the cyclists en route, the users of the improved or added infrastructure (Kesten et al., 2015). The present study is an example of the latter.

The present study attempts to identify modal share changes after bicycle infrastructure improvements, although it has several important differences compared to previous studies. Firstly, we investigate behaviour in a society with an already high cycling modal share. Consequently, we would expect the short-term modal shift to be smaller. Furthermore, in the studied region, commuting is the main reason for cycling. In addition, the weather conditions were included as explanatory variables. In accordance with previous studies (Brandenburg et al., 2007; Meng et al., 2016; Miranda-Moreno and Nosal, 2011; Nielsen et al., 2016; Thomas et al., 2013; Thomas et al., 2009) weather conditions include daily measures of sun hours, precipitation and average temperatures. We did not include wind since it was expected to have contradictory influence (contrary and tailing winds will have opposite effect). Thomas et al. (2013) and Thomas et al. (2009) include wind velocity. Not as a single factor, but as part of an aggregated indicator of the weather. Like Miranda-Moreno and Nosal (2011) the present study includes time of year, week and day as explaining factor and the weekday/weekend ratio as in indication of commute vs recreational cycling. This study further adds a ratio of rush hour/non-rush hour for the same purpose. Correcting for climate and temporal variation may, therefore, be essential for analysing the effect of improved infrastructure. Finally, bicyclists' user-experience and satisfaction are also investigated.

The study is based on an assessment of changes in bicycle volumes as well as bicyclists' behaviour/experiences following two bicycle infrastructure improvements in Copenhagen, Denmark. The two case projects addressed are examples of projects which aim to create or improve infrastructures, i.e. develop connections of (existing) bicycle facilities across a larger region. One of the two – the "Albertslund Route" - is an example of an 18 km radial route which is part of the scheme 'Cycle highways of Greater Copenhagen' (Cycle Super Highways, 2013). The other – "Vestvolden" – is a 15 km tangential route on the periphery of the metropolis area of Copenhagen, which was upgraded as part of the 'Copenhagen Fortification Project (2013) (See Fig. 1).

The assessment is based on data from counting stations over a period of 35 months before and after the infrastructure improvements and questionnaires to bicyclists before and one and two years after.

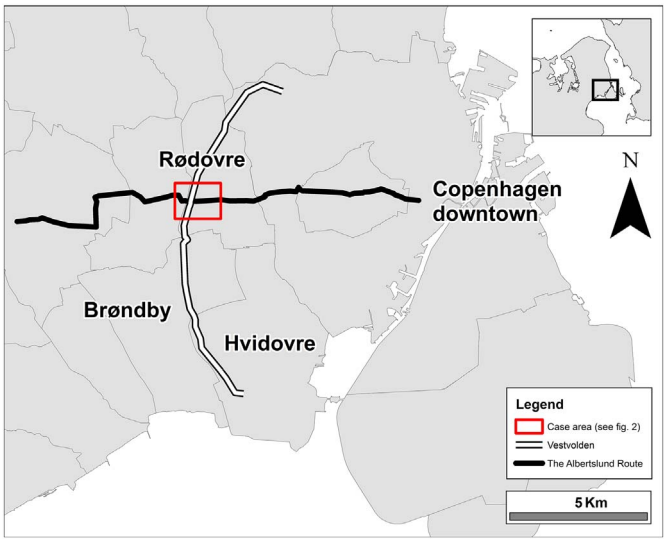

Fig. 1. Location of Vestvolden and the Albertslund Route in the Copenhagen region.