Transportation Research Part A 43 (2009) 468–480

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

A cost–benefit analysis of the Stockholm congestion charging system

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ARTICLE INFO

Article history:
Received 9 September 2008
Accepted 24 November 2008

Keywords:
Congestion charges
Road pricing
Cost–benefit analysis

ABSTRACT

This paper presents a cost–benefit analysis of the Stockholm congestion charging system, based on the observed rather than on the model-forecasted data. The most important data sources are travel time and traffic flow measurements made in the year before the charges were introduced (during April 2005) and during the first spring with the charges (during April 2006, 4 months after the charges were introduced). Using matrix calibration, effects on the non-observed link flows and travel times are extrapolated, enabling us to calculate the social value of changes in travel times and travel costs. Impacts on traffic safety and emissions are calculated using standard Swedish CBA relationships. The system is shown to yield a significant social surplus, well enough to cover both investment and operating costs, provided that it is kept for a reasonable lifetime: investment and startup costs are "recovered" in terms of social benefits in around 4 years.

1. Introduction

The so-called *Stockholm trial* consisted of two parts: a congestion charging scheme that was in place between 3 January and 31 July 2006, and an extension of the public transport supply that was in place between 31 August 2005 and 31 December 2006. The trial was followed by a referendum (the result of which is reported and described in Eliasson et al., 2009). The charges were then reintroduced as a permanent system on 1st August 2007.

A general description of the charging system can be found in Eliasson et al. (2009). It consisted of a cordon around the centre of the city of Stockholm, with a charge imposed 6.30–18.30 weekdays. The charge was 20 SEK during peak hours and 10 SEK during off-peak, levied in both directions across the cordon. The maximum amount payable per vehicle and day was 60 SEK. Various exemptions (for e.g. taxis, buses, and alternative-fuel cars and for traffic between the island of Lidingö and the rest of the county) meant that about 30% of the passages were free of charge.

The purpose of this paper is to present a cost–benefit analysis (CBA) for the congestion charging system. What separates this from most other transport investment CBAs is that it rests mainly upon measured data – that is, not on modelling results. Most of the data stem from extensive traffic measurements during April 2005 and April 2006. The first underlying assumption is that the changes in traffic between 2005 and 2006 were only due to the introduction of the congestion charges. These assumptions are discussed in Section 6, where we argue that even if there are other factors affecting the traffic between the two years, they are likely to be small in comparison. The second underlying assumption is that the effects that could be seen during the period when the charges were in place will remain also in the future. Obviously, the analysis presented here are only based on short-term effects. There are relevant reasons to argue both that long-term effects may be higher and that they may be lower. Long-term effects are also discussed in Section 6.

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doi:10.1016/j.tra.2008.11.014

A particular potential problem is separating the effects of the charges from the effects of the transit extension. The costs and benefits of the public transit extension as such are not analysed in this paper, although we take into account the increased transit crowding caused by the charges, and the extent to which this was ameliorated by the extended train services. The extension of train services was a comparably small part of the public transit extension (63 mSEK of over 1300 mSEK), while almost all the rest of the cost went to the purchases of new buses and operating costs for new bus lines. Since the congestion charges were postponed (due to legal complaints on the tendering process), it so happened that the public transit extension started earlier than the congestion charges, and its effects on car traffic could hence be separated out. It turned out that it had no measurable effect on car traffic at all, a finding which was corroborated by on-board surveys, where only 4% of the passengers stated that they were "former car drivers" (Brundell-Freij and Kottenhoff, 2009). Since the new bus lines had around 14000 boardings per day during spring 2006, this would mean that the effect of the new bus lines on car traffic amounted to somewhere around 600 car drivers per day. Comparing this to the decrease in car traffic caused by the charges (around 100000 less vehicles per day across the cordon during charged hours), it seems safe to assume that the traffic decrease was virtually exclusively caused by the charges, and the travel time gains in the cost–benefit analysis can hence be attributed to the charges.

Section 2 discusses investment and operating costs, and Section 3 the marginal cost of public funds. Section 4 presents in some detail the main benefit, namely the time gains. Section 5 presents other benefits – effects on traffic safety, emissions, transit crowding, etc. Section 6 discusses short- vs. long-term effects, and whether traffic was affected by other external factors between 2005 and 2006. Section 7 summarises all costs and benefits, and conclusions are drawn in Section 8.

1.1. Previous research

It is well known that optimal road pricing on a congested road will yield a social surplus, on an aggregate level. However, it is not evident that this holds for a real road pricing system, with its inevitable shortcomings. First, investment and operations costs may be higher than the social surplus resulting from the reduced congestion. Second, physical, technical, political and informational restrictions on the design of the charges will prevent theoretically optimal pricing. In fact, an ill-designed charge system may very well do more harm than good by inducing more congestion on non-charged roads than what is alleviated on the charged ones (Rich and Nielsen, 2007; Eliasson, 2000). Third, the standard transport economics textbook argument does not take unpriced effects on other markets into account, such as effects on the labour market (Parry and Bento, 2001) or crowding costs in the transit system. In this study, we will not study second-order effects outside the transport sector (e.g. effects on the labour and housing markets), but all the other considerations are a major part of the motivation for the study – in other words, whether the value of the travel time savings by the particular system implemented in Stockholm is enough to offset investment and operating costs, increased congestion on ring roads and increased crowding in the transit system.

There is a remarkable scarcity of published results on the welfare effects of real-world congestion charging schemes, where the value of time gains and environmental effects are compared to the cost of the system – at least compared to the vast literature on theoretical issues, equity effects, acceptability, etc. One exception is the London system: a cost–benefit analysis of the London congestion charging system was carried out by Transport for London (TfL, 2003), resulting in an estimated yearly benefit of 70 m€ (including investments and capital costs through the contract with Capita). A completely different result was obtained by Prud'homme and Bocarejo (2005), which obtained a net yearly *loss* of 80 m€. As shown by Mackie (2005) and Raux (2005), the main difference between the two results lies in the calculation of time gains (where Prud'homme and Bocajero do not include time gains outside the charged area, and also calculate smaller time gains inside the area than TfL) and the value of time used (where Prud'homme and Bocajero use a lower value of time than TfL, especially for business trips and distribution traffic).

Wilson (1988) analyses partial welfare effects (excluding commercial traffic) of Singapore's old pricing system, based on area licensing, concluding that it may have reduced welfare, since scheduling costs are higher than the value of time benefits. (The area licensing system was replaced by electronic charges in 1997.) Ramjerdi (1995) analyses welfare effects of the Oslo toll system introduced in 1989, concluding that the value of small congestion reduction is outweighed by the costs for toll collection. This is hardly surprising, since the Oslo was designed to raise revenues rather than to improve traffic conditions.

Model-based calculations are more common, even if not many analyses compare travel time benefits with estimated investment and operating costs. Of particular interest are studies from Oslo, since they can be compared with actual operations costs (around 100–150 mSEK/year, including investment costs). Grue et al. (1997) analyse a time-differentiated version of the Oslo cordon toll, calculating social benefits to be 380 NOK/capita/year (around 370 mSEK/year in total), only including time gains. Minken et al. (2001) analyses a similar system, estimating the value of time gains to 593 NOK/capita/year (around 580 mSEK/year in total). The difference stems from using different transport models and Grue's CBA methodology to be simpler (Minken et al., 2001).

Rich and Nielsen (2007) is also a model-based study, but special in the sense that it also includes benefits of traffic safety and reduced emissions, and compares the total benefits with anticipated investment and operating costs. The authors conclude that the scheme designs should be refined, since time gains do not outweigh the losses for evicted travellers (even after an assumed lump-sum transfer of revenues). When other benefits are taken into account, such as reduced emissions and accidents, total benefits increase, but still do not outweigh the estimated investment and operating costs for the systems.