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Accuracy of congestion pricing forecasts

Jonas Eliasson [a,*], Maria Börjesson [a], Dirk van Amelsfort [b], Karin Brundell-Freij [b], Leonid Engelson [a,b]

[a] Centre for Transport Studies, KTH Royal Institute of Technology, 10044 Stockholm, Sweden
[b] WSP Analysis & Strategy, Arenavägen 7, 12188 Stockholm, Sweden

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ABSTRACT

This paper compares forecast effects of the Stockholm congestion charges with actual outcomes. The most important concerns during the design of the congestion charging scheme were the traffic reduction in bottlenecks, the increase in public transport ridership, the decrease of vehicle kilometres in the city centre, and potential traffic effects on circumferential roads. Comparisons of forecasts and actual outcomes show that the transport model predicted all of these factors well enough to allow planners to draw correct conclusions regarding the design and preparations for the scheme. The one major shortcoming was that the static assignment network model was unable to predict the substantial reductions of queuing times. We conclude that the transport model worked well enough to be useful as decision support, performing considerably better than unaided "experts' judgments", but that results must be interpreted taking the model's limitations into account. The positive experiences from the Stockholm congestion charges hence seem to be transferable to other cities in the sense that if a charging system is forecast to have beneficial effects on congestion, then this is most likely true.

1. Introduction

Congestion charging is often advocated as an efficient way to combat road congestion. Many cities around the world have considered it and quite a few have introduced it, either as systems covering the city centre (e.g. London, Stockholm, Singapore) or as systems covering single links or lanes (e.g. Melbourne, Toronto, the "value pricing" systems in the United States).

Even if the general principle of marginal cost pricing is simple enough, designing a real-world system with all its necessary simplifications is a difficult task. Since investment costs and political stakes are usually high, there may only be one chance to get the design "right", in the sense that the system delivers tangible benefits without creating new problems such as substantial traffic rerouting or transit crowding. The complexity of the transport system and the large number of possible design variables make the use of transport models essential. This raises the question: are transport models sufficiently reliable to be used as decision support when designing congestion charging systems and deciding whether to implement such a system?

We explore this question by comparing predicted and actual effects of the Stockholm congestion charging system. The central question of the paper is whether the transport model allowed correct conclusions to be drawn regarding the design and preparation of the charging scheme. Hence, the comparison is structured according to the issues that were the main questions during the design and preparation process, such as whether the reduction of car traffic would meet the target, whether there would be capacity problems in the public transport system, whether traffic would decrease within the inner

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[*] Corresponding author. Tel.: +46 8 7906835.
E-mail address: jonas.eliasson@abe.kth.se (J. Eliasson).

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city, and whether congestion on circumferential roads would increase. The question whether the model was "good enough" can be interpreted as "if planners had had access to a perfect model, able to perfectly predict the effects of the charges – had the system been designed differently, or had different preparations been made?".

However, the purpose of this paper goes beyond mere model validation and development. From a policy perspective, the crucial question is whether the positive Stockholm experiences – where the charges resulted in substantial congestion reductions – are transferable to other cities. Obviously, introducing a copy of the Stockholm system in another city would not give precisely the same effects. But if transport models can be trusted to predict the effects of congestion charging systems reliably enough, then a best-practice transport model for another city should be able to predict what effects congestion charges would have in *that* city. There are hosts of model-based analyses of congestion charging schemes for cities around the world (e.g. de Palma et al., 2006; Santos et al., 2001; Rich and Nielsen, 2007; Eliasson and Mattsson, 2006; Fridstrøm et al., 2000; Kickhöfer et al., 2010), but predictions are often met with scepticism from decision-makers and the public. Before the charges, Stockholm was no exception: predictions that relatively low charges would lead to substantial reductions of congestion were widely disregarded. The ulterior motive of this model validation exercise is to contribute to this debate, and enable cities to make informed assessments of the potential benefits of congestion charges and how a system should be designed.

Despite transport models' importance as decision support, there are not many published studies providing detailed analyses of the validity of transport model predictions. Moreover, virtually all such studies deal with physical investments such as new roads or railways. An exception isLeape (2006), who in a review of the London experiences notes that the forecast of a 10–15% reduction of vehicle miles in the charged area turned out to be accurate. The present paper hence seems to be the first detailed study of a transport model's ability to forecast the effects of an urban congestion charging system. Bain (2009), Bain (2011) and Li and Hensher (2010) compare forecasts and outcomes for a large number of toll roads, finding that forecasts tend to overpredict actual patronage. This seems to be less due to shortcomings of models than to various forms of optimism bias, including psychological effects and winner's curse (the most overoptimistic bidder wins a toll road concession).

Flyvbjerg et al. (2005) analyse a large collection of forecasts and outcomes for rail and road investments, finding systematic overpredictions of demand for new infrastructure projects, in particular for rail projects. They conclude that the main culprit seems to be incentives to strategically misrepresent demand forecasts caused by institutional structures, such as competition for public funds, rather than poor prediction techniques. Van Wee (2007) also finds that the accuracy of transport demand forecasts is poor, especially for rail projects, concluding that the problems are not primarily by shortcomings of the forecasting models, but opportunities and incentives for strategic behaviour due to formal and informal structures.

An informative case study of such strategic misrepresentation is provided by Kain (1990), relating the story of how demand forecasts for a railway were exaggerated by tinkering with the land use scenarios used in the transport model. However, the fact that these studies point to strategic mishandling of models as the main source of errors mean that they do not provide much guidance as to models' actual forecasting capabilities, although Bain (2009) and Bain (2011) also quote overestimation of drivers' willingness-to-pay as one reason for overpredicting traffic on toll roads. Contrary to the studies above, Parthasarathi and Levinson (2010) find that forecasts tend to underpredict actual traffic, in a study of a large number of Minnesota roads. The reasons for underprediction are unclear, but erroneous scenario assumptions seem to be a major source of error. Turning to case studies of specific investments, Pedersen et al. (2001) compare forecasts and outcomes for the Danish Great Belt link, noting a slight underprediction of trips. Anguera (2005) study the Channel Tunnel, showing that the substantial overprediction of traffic and revenues was due to neglecting the competitive price response of Channel ferries combined with massive overprediction of total market growth. Petersen (2010) compares forecasts for the Danish-Swedish Öresund bridge with actual outcome, noting that political visions seem to have affected what forecasts to use.

Model validation often becomes difficult due to long time lags between forecast and start of operation. Input parameters such as population, land use, fuel prices, fares, and levels of service may be different in reality than was assumed in the forecast. Moreover, it is often difficult to get detailed information of outcomes, forecasts and underlying scenario assumptions (Parthasarathi and Levinson, 2010). As a contrast, the introduction of the Stockholm congestion charging system provides an unusually good opportunity for model validation. First, the effects of the charges were measured in an extensive evaluation program, gathering all sorts of data on traffic flows, travel times, travel patterns, etc. Secondly, the forecast was made shortly before the introduction of the charges, eliminating the problem of errors in input parameters or scenario assumptions. Thirdly, we know precisely how the model was used as decision support: what questions it was used to analyse, how results were interpreted and what conclusions were drawn. This makes it possible to focus on those model aspects and outputs that were most important from the point of view of the users. For the reasons stated above, this paper evaluates the model forecast against the short-term effect of the congestion charges. The actual effects of the charges are taken to be the differences between measurements from the spring of 2005 (without charges) and measurements from the spring of 2006 (with charges). Previous analyses have shown that other factors than the charges made very little difference to the change in traffic levels between 2005 and 2006 (Eliasson, 2009a). Moreover, the effects of the charges seem to have remained virtually unchanged over time (Börjesson et al., 2012). Hence, no rebound effect is observed in the sense that new car traffic has been attracted in the longer run.

The paper is organised as follows. Section 2 describes the Stockholm congestion charging system and the transport model used for the forecasts. Section 3 compares forecasts with outcomes. Section 4 summarises the findings and concludes.