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Efficiency vs equity: Conflicting objectives of congestion charges

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ABSTRACT

This paper analyses the trade-off between equity and efficiency in the design of the Stockholm congestion charging systems. Comparing different designs for Stockholm, the paper shows that the most efficient system is the least equitable. Indeed, we show that moving towards a more efficient system design favours high-income-users most. The reason is the uneven distribution of workplaces and residential areas, combined with richer socio-economic groups living in areas with more workplaces. Hence, the conflict between efficiency and equity of this policy arises from the spatial mismatch of residential areas and locations of employment, and the spatial separation between low-income and high-income groups that characterise most cities. This paper shows that these spatial patterns have a large effect on the distribution effects of the congestion charges and that the system design can have a major impact on equity.

1. Introduction

In this paper, we explore the trade-off between vertical equity and efficiency of the Stockholm congestion charges using a large scale and dynamic transport model. Most previous equity analyses of congestion charges study the distribution effect arising from differences in the value of travel time (VTT) (Verhoef and Small, 2004) and mode choice (Eliasson and Mattsson, 2006). Our contribution to this literature is that we instead study the distribution effect of costs and benefits depending on geographic location and charging levels of the system, which are controlled by the system designer.

There is a general concern that congestion charges often are regressive, i.e. total payment relative to income decreases with increasing income.[1] Arnott et al. (1994), Giuliano (1992), and Small (1983) also point out that congestion charges are likely to benefit high-income citizens in cities where driving patterns of low-income and high-income citizens are similar, simply because low-income groups are more likely to be priced off the road due to low VTT.[2] Later studies on congestion charging dealing with equity have discussed public resistance (Viegas, 2001; Oberholzer-Gee and Weck-Hannemann, 2002), negative distribution effects arising from differences in VTT (Verhoef and Small, 2004) and distribution of toll payments across income groups (Eliasson, 2016). In particular, Eliasson find that high-income groups pay more than low-income groups in all cities in the study (Stockholm, Helsinki, Lyon and Gothenburg), but that low-income groups pay the largest share of their income in all cities.

Sumalee (2003) notes that distributional effects can be seen as a constraint on to what extent efficiency and environmental objectives of congestion charges can be fulfilled. Levinson (2010) and Ison and Rye (2005) underscore that the distribution of costs and benefits of a charging system depends on the design of the system, including for instance exemptions and discounts. Furthermore, there are some studies that investigate both efficiency and equity of congestion pricing, e.g. for Washington DC (Safirova et al., 2004), Utsunomiya area in Japan (Maruyama and Sumalee, 2007), Stockholm (Eliasson and Mattsson, 2006; Franklin, 2005), a comparison for Cambridge, Northampton and Bedford (Santos and Rojey, 2004) and Gothenburg (West and Börjesson, 2016). However, there is no literature that, like the present paper, explicitly explores the trade-off between efficiency and distribution of gains and losses in design of a charging scheme for a specific area.

Another example where equity impact of a policy depends on the geographical distribution of income is the fare structure of public transport, e.g. flat versus distance-based public transport fares. Some studies have found that distance-based public transport fares benefit low-income groups more than high-income groups (Bandegani and Akbarzadeh, 2016; Farber et al., 2014), however, this will depend on the spatial mismatch between different income groups and the labor market. The reversed results might be found in cities where low-income

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[1] Suits (1977) uses this definition of a regressive/progressive instrument.
[2] This is often the case in cities with low public transport shares, since in these cities car dependency is high also among low-income groups.

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households are located in remote areas, depending on the locations of employment (Sanchez et al., 2007). Litman (2016a) finds that a conflict often occur between efficiency and equity objectives of public transport investments, where investment in major urban corridors typically are most efficient but benefit more affluent users, whereas investments in services for disadvantaged groups (e.g. elderly with low mobility) typically are less efficient.

In this paper, we do not analyse distribution effects arising from the differences in VTT due to income differences, implying that we assign equal weights to travel time gains in all income groups. However, we do consider preference differences across travellers that do not arise from income differences. Otherwise we would underestimate the benefit of congestion charges arising from sorting (Verhoef and Small, 2004; Börjesson and Kristoffersson, 2014).

We find that the more efficient systems (generating higher welfare) have larger negative distribution effects. The results are driven by a spatial mismatch, where high-income citizens tend to live within the inner city and to the north, where also most workplaces are located. We further explore how four different revenue strategies influence the distribution of cost and benefits across income groups (lump sum, a general reduction in costs for all car trips, reduced costs for public transport trips and income tax cut). We find that the tax cut refund strategy benefits the high-income group much more than the other refund strategies. The distribution effects of the other three strategies are similar, because there are no large differences in the number of car trips and public transport trips across income groups.

While this paper shows results specific to Stockholm, the conflicting objectives between equity and efficiency depending on city structure and income segregation has not previously been studied, and is likely to be a general problem in many cities. Income levels differ substantially between different neighbourhoods in virtually all cities, and in most cities also congestion varies depending on directions and location. Hence, we believe that this is a general problem facing congestion charging system designers in many cities, much like the structure of public transport fares. It is probably also one reason why the most efficient systems would be difficult to implement in many cities, as it is in Stockholm. Still, Börjesson et al. (2015) and Hess and Börjesson (2017) find that although equity concern is an argument against congestion charges, it is not the main factor determining the public support in Sweden, Finland or in France (although equity concerns are stronger in France). The public support for congestion charges seems to be more dependent on the general political attitudes and views related to concern about environment and taxes.

The paper continues in the next section with a short description of the Stockholm congestion charges. Section 3 then describes the theory behind the main concepts of the paper: efficiency and equity. The methodology, including scenario and model description, is described in Section 4. Section 5 reports and analyses the results of each scenario and Section 6 concludes.

2. The Stockholm charges

The Stockholm congestion charges were introduced as a trial in 2006 (Eliasson et al., 2009) and made permanent from autumn 2007 (Börjesson et al., 2012). By the time of introduction, the scheme consisted of a simple cordon around the inner city. The peak hour charge was 2.0 EUR[3] per crossing, the shoulder charge 1.5 EUR and the off-peak charge 1.0 EUR (see Fig. 1). The same amount was charged at all points and for both inbound and outbound driving directions. The Essinge bypass motorway (solid line in Fig. 1) was free of charge.

The short- and long-term effects of congestion charges in Stockholm are described in Eliasson (2009) and Börjesson et al. (2012) respectively. Börjesson and Kristoffersson (2015) compare the effects in Gothenburg to the Stockholm effects.

[3] Throughout the paper 1 SEK is converted to EUR using the conversion rate 0.1.

From January 2016, a charge is also levied on the Essinge Bypass and the charge on the cordon around the inner city has been increased, especially during peak hour with a current peak hour charge of 3.5 EUR. For a description of the effects of the increase and extension of the charge see Börjesson and Kristoffersson (2017).

3. Theory

The two key concepts in this paper are efficiency and equity. By efficiency we mean socio-economic efficiency, defined as the total change in consumer surplus (including time gains, paid charge and adaptation costs) plus revenues. Hence, the system design resulting in largest social surplus will be considered the most efficient design.

Equity is a fuzzy concept, and less straightforward to define. Equity measures are often based on the distribution of benefits and costs, and some would argue that an equitable system is a system where the distribution effects are seen as fair. However, as Eliasson (2016) points out, there is no objective definition of what a fair policy is. Whether a given distribution effect is considered fair might for instance depend on whether the policy is introduced mainly for fiscal reasons or as a price correction (although in most cases it is both). If the policy is implemented for fiscal reasons, it might be seen as less fair (and inequitable) if low-income groups pay more relative to their income than high-income users. If the policy is a price correction mechanism, this is not necessarily unfair, since low-income groups may cause more externalities.

Equity is often categorized as horizontal or vertical (Litman, 2016b). A transport policy that is horizontally equitable distributes costs and benefits equally across all individuals. A policy that is vertically equitable favours groups that are socially or economically disadvantaged, for instance low-income groups. Litman further categorizes vertical equity into i) Vertical with-respect-to income and social class and ii) Vertical with-respect-to need and ability. These two types of vertical equity are typically evaluated through a welfare-based approach and a transportation access approach respectively (Ecola and Light, 2009). The welfare-based approach focuses on distribution of gains and losses across various dimensions. The transportation access approach concentrates on individuals that are disadvantaged in the transportation system, may it be because of no access to car or driver's licence, gender, age, ethnicity or another reason (Rajé, 2003). Common methods used in the transportation access approach are surveys and focus groups with representatives of individuals that are disadvantaged in the transportation system.

In this paper, we use a welfare-based approach and we analyse the vertical equity by exploring the distribution of the changes in consumer surplus across income groups, when congestion charges are added to the transport system. Hence, we do not only explore how the total payments are distributed, but we also include travel time gains and adaptation costs in the distribution analysis. We evaluate changes in consumer surplus on zonal level and have access to data on zone population by income category. It is therefore possible to assess the effects of congestion charging across income groups.

Assume now that the utility function for a representative traveller with preferences i is $V = \alpha t + \gamma\sigma + \beta_i SDE + \delta_i SDL + \lambda_i c$, where t is travel time, σ is standard deviation of travel time, c is travel cost, and where SDE and SDL are schedule delay early and schedule delay late, respectively, in relation to a preferred departure time (this is the utility function of the transport model used in our analysis, see further Börjesson and Kristoffersson (2014)). Now, the marginal utilities – in our case $\alpha, \gamma, \beta_i, \delta_i$ and λ_i – cannot be observed. Dividing change in utility ΔV by the marginal utility of money we express it in monetary units:

$$\Delta V/\lambda_i = \alpha/\lambda_i \Delta t + \gamma/\lambda_i \Delta\sigma + \beta_i/\lambda_i \Delta SDE + \delta_i/\lambda_i \Delta SDL + \Delta c. \quad (1)$$

When specifically analysing distribution effects across income groups, it makes little sense to put a higher weight on the time, reliability and scheduling gains of high-income drivers. For this reason, we do not apply different valuations (values of travel time, standard deviations or