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Working Paper

Long-term effects of the Swedish congestion charges

International Transport Forum Discussion Paper, No. 2018-14

Provided in Cooperation with:

International Transport Forum (ITF), OECD

Suggested Citation: Börjesson, Maria (2018) : Long-term effects of the Swedish congestion charges, International Transport Forum Discussion Paper, No. 2018-14, Organisation for Economic Co-operation and Development (OECD), International Transport Forum, Paris, <https://doi.org/10.1787/d944f94b-en>

This Version is available at:

<https://hdl.handle.net/10419/194077>

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Long-Term Effects of the Swedish Congestion Charges

Discussion Paper

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Roundtable

Maria Börjesson

Swedish National Road and
Transport Research Institute

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Cite this work as: Börjesson, M. (2018) "Assessing the Net Overall Distributive Effect of a Congestion Charge", *International Transport Forum Discussion Papers*, OECD Publishing, Paris.

Acknowledgements

The author is grateful to Dr. Ida Kristoffersson, VTI, and Professor Jonas Eliasson, City of Stockholm for many fruitful discussions and joint work on the of Swedish congestion charges over many years. I also want to thank Karin Björklind, City of Gothenburg, Åke Wessman, Swedish Transport Administration, and Gunnar Söderholm, City of Stockholm, for help to access data.

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Introduction

The Swedish congestion taxes were first implemented almost 12 years ago. Time-of-day dependent cordon-based congestion charging systems were introduced in Stockholm in January 2006 and in Gothenburg in 2013. In Stockholm, the peak charge was increased by 75% in January 2016 and the system was extended significantly, to include all car traffic between the north and south part of Stockholm. In Gothenburg, the peak charge was increased by 22% in January 2015. Stockholm is a city of 2 million citizens with comparatively high congestion because the city is built on islands. Gothenburg is one of the smallest cities (half a million citizens) ever to implement congestion charges, and the congestion has always been much lower than in Stockholm. Congestion occurs mainly around the highway hub to the north of the city centre. Gothenburg is also more sparsely populated than Stockholm, and has therefore a considerably lower public transport market share and higher car dependence.

Earlier research (Börjesson et al., 2012; Börjesson and Kristoffersson, 2015) has shown that the charges initially caused substantial traffic reductions across the cordon, that these reductions increased over the first five years in Stockholm, and that the public support increased once the charges were introduced in both cities. This paper analyses the long-term trends, focusing on the effects that have not remained stable over time, and the effects of the system revisions. I compare the trends and effects between the two cities, indicating the transferability between cities.

In the first section, I describe the system design, focusing on the system revisions, and briefly reviews the short-term effects on traffic, social benefit, and distribution. The second section shows the long-term trends in operation costs and revenues.

The third computes the long-term price elasticities for different types of traffic (company cars, light and heavy trucks and private passenger cars). I find that the price elasticities have increased over time in Stockholm, but decreased in Gothenburg. Company cars and trucks are relatively insensitive to the charges.

There is some literature on the effectiveness of congestion charges in reducing traffic volumes in Singapore (Phang and Toh, 1997), London (Santos, 2004; Santos and Shaffer, 2004), Stockholm (Börjesson et al., 2012; Eliasson, 2009) and Milan (Gibson and Carnovale, 2015). Janson and Levinson (2014) review a number of elasticity estimates for toll roads in the US and find them to be -0.30 to -0.36, which is lower than what is found for the European congestion charging systems. Analyses of long-term effects of congestion charges are scarce. However, in consistency with my findings from Stockholm, Odeck and Bråthen (2008) find that the short-term elasticity of -0.45 is lower than the long-term elasticity of -0.82 for the Norwegian toll projects. Goodwin et al. (2004) find that the long-term fuel price elasticities are higher than in the short term; presumably travellers have more possibilities to adapt their behaviour in the long term.

This is followed by a comparison of the elasticities observed when the systems were revised with those observed when they were first introduced. Evidence from London (Evans, 2008) and Singapore¹ indicates small demand effects in response to adjustments in pricing levels. Janson and Levinson (2014) even find a positive price elasticity of toll increases MnPASS High Occupancy Toll (HOT). They explain the positive price elasticity by travellers expecting a higher travel-time saving on the toll road when the price is high. I

find that the behavioural effect of extensions and further increases in the charging levels is diminishing; a likely reason being that the most price-sensitive traffic was already priced off the road at the introduction. As shown in Section 2, the transaction costs of the systems are small.

The fourth section describes how the public and political support has evolved over time. I show that the public support increased in the two cities after their introduction until the systems were revised; since then, the public support has declined in both cities. In Stockholm, this was a trend break after almost a decade of increased support for the charges.

In this paper I leave out effects on land-use because they seem negligible even after a decade, although there were concerns that the charges would reduce the attractiveness and economic activity of the city (Eliasson, 2008). Comparing travel survey data from 2004 and 2015 (almost a decade after the introduction) Bastian and Börjesson (2017) find that the reduction of car trips is more than compensated by an increase in bicycle and public transport trips to and from the inner city; similar trends were observed for London (Transport for London, 2015, p. 24). Hence, the share of trips to and from the inner city has in fact increased. We still don't know what the share of trips to the inner city had been had the charges not been introduced, but there is no reason to believe that the congestion charges have had any substantially negative impact on land use, agglomerations, or the economy. Moreover, Anderstig et al. (2016) show that the charges themselves have in fact had positive effects on labour income, because it is the most productive travellers that have received time gains (the most valuable trips are not priced off the road and the time savings are valuable).

The final section summarises the key findings relevant for whether the charging system should be further extended, and what other cities can learn from the Swedish experiences.

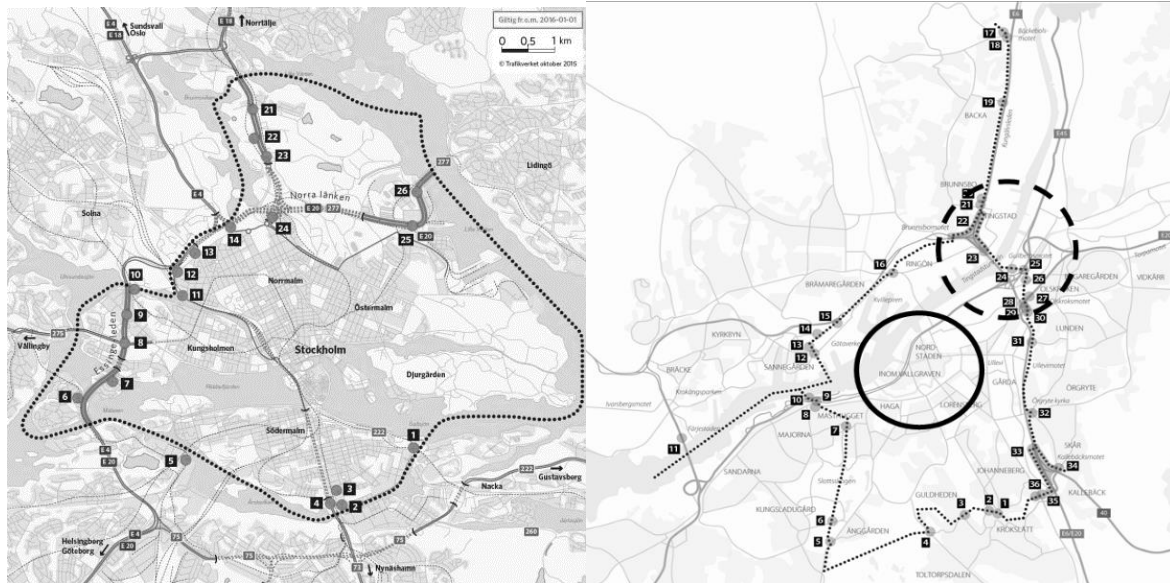
System design is difficult, in particular in cities like Gothenburg

The system design impacts efficiency and distribution effects

The Stockholm system was introduced in January 2006, and designed as a toll cordon around the inner city (see the dotted line in Figure 1). Charges are time-dependent and levied 6:30-18:30 on weekdays. Vehicles are charged when crossing the cordon in both directions. Since January 2016, a charge has also been levied on the Essinge bypass (E4/E20), which is a heavily congested motorway located west of Stockholm city centre, depicted in green between points 6 and 10 in Figure 1. Stockholm is built on islands, and the Essinge bypass is the only bridge between south and north of Stockholm, except through the inner city. There are several bottlenecks on the Essinge bypass and it operates close to capacity for a substantial part of the day. It was left out of the initial 2006 charging system for political reasons. Back in 2006, the decision makers thought that it was essential for public acceptance to keep the bypass uncharged, as the only uncharged route between southern and northern Stockholm. Because the additional revenues are used for further infrastructure investments (from page 19) charges were introduced on the bypass (possibly also due to the increasing public support for the charges and increasing congestion on the bypass).

From 2006-15, the charge ranged between EUR 1 and EUR 2 per passage, but in January 2016 the charging levels were increased to range from EUR 1.1 to 3.5 per passage.² Hence, the charge increased by 75% in the peak but only 10% in the off-peak. The maximum charge for one day also increased from EUR 6 to 10. The charge on the Essinge bypass is slightly lower than the charge on the cordon during peak hour (EUR 3.0). To further discourage drivers travelling between south and north to travel through the inner-city cordon, the inner-city route choice requires two passages but the Essinge bypass only one.

Figure 1. Tolling boundaries for the Stockholm and Gothenburg systems



Note: Dotted lines = toll cordon. Stockholm (left): cordon around the inner city and on the bypass (the latter marked with thick line). Gothenburg (right): dashed circle marks the bottleneck highway hub; solid circle marks the inner city.

The Gothenburg system consists of a circle cordon with two antlers (the latter to avoid rat-running³ through the inner city). The congestion has always been lower and more local in Gothenburg, and occurs mainly around the highway hub to the north of the city centre. Vehicles are charged when crossing the cordon in both directions. Charges are time-dependent and levied 6:00-18:30 on weekdays. In 2013 and 2014 the charge ranged from EUR 0.8 to 1.8, but since 1 January, 2015 the charge ranges from EUR 0.9 to 2.2 per passage. The charge was increased by 22% in the peak but only 13% in the off-peak. The maximum charge has been EUR 6 since the introduction and a multi-passage rule states that if passing the cordon more than once within 60 minutes, only the highest charge has to be paid.

Stockholm and Gothenburg use the same system administration and technology Automatic Number Plate Recognition (ANPR). Users have signed up (25%) for direct debit (Source: The Swedish Transport Agency), which is completely automatic. The default payment option, used by the other 75% of the users is that they are sent a monthly invoice covering the total monthly charge. Currently 66% of the invoices are electronic (The Swedish National Financial Management Authority, 2016), and are paid with just one click using internet banking. Altogether, this means that only 25% of the users pay the charge manually by a paper invoice and that the transaction cost of paying the charge is generally low.

Table 1. Charge (EUR) depending on time of day

	Stockholm			Gothenburg	
	Inner-city cordon 2006	Inner-city cordon 2016	Essinge bypass 2016	Cordon 2013	Cordon 2015
06:00–6:29	0	0	0	0.8	0.9
06:30–6:59	1.0	1.5	1.5	1.3	1.6
07:00–7:29	1.5	2.5	2.2	1.8	2.2
07:30–8:29	2.0	3.5	3.0	1.3	1.6
08:30–8:59	1.5	2.5	2.2	0.8	0.9
09:00–9:29	1.0	1.5	1.5	0.8	0.9
09:30–4:59	1.0	1.1	1.1	0.8	0.9
15:00–5:29	1.0	1.5	1.5	1.3	1.6
15:30–5:59	1.5	2.5	2.2	1.8	2.2
16:00–6:59	2.0	3.5	3.0	1.8	2.2
17:00–7:29	2.0	3.5	3.0	1.8	2.2
17:30–7:59	1.5	2.5	2.2	1.3	1.6
18:00–8:29	1.0	1.5	1.5	0.8	0.9
18:30–5:59	0	0	0	0	0

An important aspect of the system design is the charging rules applying to company cars used for private trips. In this paper, I define a company car as a passenger car owned by a legal person and that is not used as a taxi. Company cars make up 37% (Stockholm) and 21% (Gothenburg) respectively of all passenger cars crossing the cordon.

In some sectors, it is common for company cars to be at the disposal of households as a fringe benefit for the employees. According to travel surveys, 8% of the citizens of Gothenburg and 10% of the citizens of Stockholm have access to a company car in the household to be used for private trips. According to a court decision in 2008, congestion charges for company cars used for private trips are already included in the fringe benefit, which company car drivers are taxed for.⁴ This has meant that even if the firm (or leasing firm) pays the congestion charge, the driver is not taxed for this benefit. It has resulted in negative effects on the income redistribution of the policy: 75% of company car drivers belong to the top three (out of eleven) income classes (Ynnor, 2014). This has reduced the effectiveness of the charges. For this reason, new legislation will come into force in January 2018 whereby company car users are taxed when the employers pay the congestion charge for private trips (including commuting) (Ministry of Finance, 2017). It remains to be seen if this will be enforced by the tax authorities.

The legislation regarding company cars used for private trips demonstrates that the distribution of costs and benefits of a charging system depends on the design of the system, including exemptions and discounts (Eliasson, 2016; Ison and Rye, 2005; Levinson, 2010).

In both Stockholm and Gothenburg more than ten systems were evaluated and discarded because model prediction indicated that they would cause severe second-best problems: for instance, causing more

congestion in the network. The topography of Gothenburg complicates the design of the system, and induces more unwanted second-best effects than in Stockholm. The Stockholm cordon, surrounding the inner city (where the bottlenecks are located) cuts through the water. The water works as a natural border, preventing the cordon from inducing undesirable barriers and route choice effects. For this reason, Stockholm is the ideal city for congestion charges. In Gothenburg, however, there are no such natural barriers where the bottlenecks are located, causing unpopular barriers within residential areas. The lack of natural barriers also implies that more checkpoints are needed in Gothenburg (38 compared to 18 in Stockholm) to avoid rat-running within residential areas.

Positive traffic effects – negative distribution effects

When the charges were introduced in Stockholm in 2006, the traffic across the cordon was reduced by approximately 20% (Eliasson et al., 2009). In Gothenburg, the reduction in traffic volume across the cordon was by approximately 12% (Börjesson and Kristoffersson, 2015). The charges reduced the queuing time and travel time variability with 30-50% on the bottleneck links in both cities. But in Stockholm the travel time reductions occurred in a much larger part of the network than in Gothenburg, mainly because many intersections were blocked upstream of the bottlenecks (often more than 10 km from the bottlenecks) prior to the introduction of the charges.

The adaptation mechanisms observed in Stockholm and Gothenburg are remarkably similar: commuters diverted to public transport (but contrary to prior expectation only approximately 50% of the drivers are commuters) and discretionary travelers adapted in other ways. This result is supported by a model-based study (Börjesson et al., 2014), showing that the traffic effects and adaptation costs are surprisingly stable across different types of traffic systems (with different public transport shares and capacity on the bypasses).

The price elasticity observed the first year is similar in the two cities: -0.87 in Stockholm and -0.69 in Gothenburg (Börjesson and Kristoffersson, 2017). Moreover, the elasticity in the off-peak is 1.7 times higher than the peak elasticity in both cities (-1.13/-0.67 and -0.93/-0.53 respectively). The same pattern is found for the Essinge bypass when the charges were introduced there. The higher price elasticity is a result of the same percentage traffic volume reduction although the charge is lower in the off-peak.

In Stockholm traffic declined even in the free-of-charge evenings. Even more interestingly is that when the charges were increased in 2016 only in the peak, the traffic volume reduced 5% in the peak and in the off peak! Hence, on the aggregate level there is no sign of changes in departure time as an adaptation strategy. Data from the systems support the hypothesis that the seemingly high price-elasticity in the off-peak is largely a result of off-peak trips paying the peak charge in the other direction.⁵ This explanation would also account for the less accurate predictions in the off-peak (Eliasson et al., 2013; West et al., 2016).

The similarity of elasticities and adaptation strategies is particularly interesting given the large difference in public transport market share, which is approximately 75% for peak hour trips across the cordon in Stockholm compared to approximately 25% in Gothenburg.

The cross-price elasticity for public transport was 0.13 for Stockholm (Börjesson et al., 2015). In Gothenburg the corresponding cross-price elasticity was 0.33.⁶ The lower cross-price elasticity for Stockholm might be explained by the low market share for car to and from the inner city: for instance in a standard logit model the cross-price elasticity is proportional to the market share (Train, 2003).

Ex-post cost-benefit analyses after the first year show that the congestion charges are socially beneficial in Stockholm and Gothenburg (Eliasson 2009; West and Börjesson, 2017). The travel time savings are larger in Stockholm and the net social benefit is therefore higher. However, particularly in Gothenburg but also in Stockholm, the congestion charge is regressive (Eliasson, 2016). Lower income car owning households spend a larger proportion of their income on tolls than higher income households (although this ignores households without cars, which can be 75% of the lowest quintile (Cain and Jones, 2008)). In Gothenburg, many low-income commuters are car dependent (West and Börjesson, 2017). Most residents in Gothenburg suffer a net loss from the charges, and because the distribution of the direct effects of the charges are regressive, the spending of the revenue is decisive for the total effect on equity. However, the revenue is spent mainly on a rail tunnel with low value for money Benefit to Cost Ratio (BCR) of 0.45 (Mellin et al., 2011), which primarily gives benefits to commuters from surrounding municipalities in the regions.

In Stockholm negative distribution effects might be less of a problem because due to the high market share for public transport, most low-income commuters already used public transport before 2006. Moreover, taking into account heterogeneity in values of time and network effects the consumer surplus is slightly positive (Börjesson and Kristoffersson, 2014); many drivers are better off with the charges because the value of the time savings exceeds the charge.

The effects on the emissions cannot be measured directly because air quality depends heavily on weather conditions. It can, however, be approximated from the effects on traffic volumes. Estimates show that carbon emissions have been reduced by 2-3% in Stockholm County and in the Gothenburg region in response to the introduction of congestion charges.⁷ However, the reduction of the total emissions from car traffic in Sweden is marginal.

Rapidly declining system operating costs

The investment cost for the Stockholm system introduced in 2006 was approximately EUR 200 M (Eliasson, 2009). This cost includes the initial cost for planning and commissioning of the system (including such items as system development and staff training) and operating costs during the first year. The annual operating cost (covering maintenance and reinvestments essential to operating the system) was EUR 22 M in the second year of its operation. As explained by Hamilton (2011), one of the main cost drivers of the Stockholm system was the requirement of extremely high resilience, essential because of the high political risk. The political risk was a result of the initially low levels of public and political support, and the critical media coverage.

The investment cost of the Gothenburg system was substantially lower than that of the Stockholm system, because it was built as an extension of the well-functioning Stockholm system. The cost of the Gothenburg extension was EUR 76 M according to the Swedish Transport Agency's annual reports, but only approximately half of that is a direct cost for the Gothenburg system (infrastructure, roadside, project management, testing of the system, information and staff training). The other half (EUR 35 M) of the total budget was used for developing a new national central system for the charges. The central system of the original Stockholm system was developed and managed by IBM up until 2012. When the

Stockholm system was extended to Gothenburg (and to two new bridges in other parts of Sweden), the IBM system had to be replaced.

The investment cost in Gothenburg was from a financial cost perspective recovered in slightly more than a year (West and Börjesson, 2017). In Stockholm, the investment costs were recovered in financial terms in 3.3 years (Eliasson, 2009). The longer time to recover the investment cost in Stockholm is due to the substantially larger investment cost.

Table 2 shows that the yearly operating cost of both systems has declined gradually after introduction. The revisions of the systems increased the revenue (53% in Stockholm and 24% in Gothenburg), but affected the operation costs of the system marginally. The yearly operation cost of both systems is now 7% of the revenue in Stockholm and 11% in Gothenburg. The table also demonstrates that the number of passages is higher in Gothenburg, although the revenue is similar in the two cities. Thus, the average charge per trip is lower in Gothenburg than in Stockholm. This is due to lower charging levels and the multi-passage rule (see Section 2).

Table 2. Revenue, passages and operating cost of the systems⁸

	Revenue (M€/year)	Passages (M/year)	Operation Cost (M€/year)	Cost/Revenue (%)
Stockholm 2008	70.9	82.0	22.0	31
Stockholm 2013	86.5	77.5	10.2	12
Stockholm 2015	91.4	80.5	9.6	11
Stockholm 2016	140.0	93.4	10.3	7
Gothenburg 2013	81.0	120.0	13.8	17
Gothenburg 2014	80.0	131.0	12.8	16
Gothenburg 2015	99.5	134.0	12.5	13

The London charging system is more expensive than the Swedish systems: the latest estimate for London is a yearly (April 2015 - March 2016) operation cost of GBP 90.1 M (compared to the revenue of GBP 258.4 M, 35%) (Transport for London, 2016), which is still a large improvement from GBP 141.4 M (compared to the revenue of GBP 186.7 M, 76%) for the first year after its introduction in London (Transport for London, 2004). A key difference between the Swedish systems and the London system is that the payments of the latter are partly manual. The payments of the Swedish system are fully automated. Mackie (2005) suggests that one reason for the high operation cost is the rent-seeking behaviour of the private contractor.

Effects on traffic volume depend on many factors

In this section, the effects of the Stockholm and Gothenburg charging systems are explored by (i) comparing the long-term price elasticity trends in Stockholm and Gothenburg, (ii) comparing the price elasticity observed when the peak charging levels were increased, and when the Stockholm system was extended, with those observed at the introduction of the charges and (iii) understanding the difference in the peak and off-peak elasticity in the two cities. The arc elasticities are calculated as:

$$E_{x \rightarrow y} = \frac{\text{LOG}(D_y) - \text{LOG}(D_x)}{\text{LOG}(P_y) - \text{LOG}(P_x)}, \quad (1)$$

where x refers to the initial state, y to the new state, D is demand, P is price level and E is elasticity. Note here that I disregard the effect on travel time reductions in our calculations, and they are larger in Stockholm than in Gothenburg.

Effects increasing over time in Stockholm and decreasing in Gothenburg

A common apprehension is the effect of the charges attenuate over time, in other words that the price elasticity of traffic decreases over time. In this section we will compare the long-term and short-term effects of the charges.

Table 3 shows how the input variables in (1) (D and P for the base year 2005 and 2006-14) are computed in order to derive the price elasticity for Stockholm for the years 2006-14. To do this we take into account two factors: first, that several external factors such as population growth and fuel prices affect traffic volumes, and second, that other factors such as inflation and changes in deductibility regulations and exemptions have changed the charge level in real terms. Even so, as time passes, it becomes increasingly difficult to separate the effects of the congestion charges from other external factors. Despite this caveat, it is obviously important to know whether long-term effects are very different from short-term effects. If apprehensions are true that the effects of the charges indeed “wear off”, then this would be a considerable problem for any price-based transport policy. In the spring of 2015, some large changes in Stockholm’s transport system imply that it is not relevant to compute the elasticities for the years after 2014.

According to a time series model applied by Börjesson et al. (2012), the external factors explaining the trend in the traffic across the cordon in Stockholm are employment and relative car ownership in the county, as well as fuel price (several other variables were also tested but added no explanatory power). The total effect of these factors on the traffic volume across the cordon is shown in the first row in Table 3. The third row shows the reduction of traffic across the cordon, adjusted for external factors to the 2005 level. This row thus shows estimates of what the traffic volume would have been had the external factors remained constant since 2005. Alternative fuel cars were exempt until 2012, and in 2006 taxis were also exempt from charges. The share of exempt traffic varied between 28% and 25% between 2006 and 2011, and declined to just below 15% thereafter. The fourth row of Table 3 shows the

reduction of non-exempt traffic, adjusted for external factors to the 2005 level. I compute the elasticity for non-exempt vehicles only.

To calculate the average trip costs, excluding the congestion charge, I assume the driving cost per kilometre used by the Swedish tax authorities, EUR 0.15/km in 2006. According to a two-wave travel survey in 2004 and 2006, the average trip length for trips crossing the cordon to/from Stockholm inner city remained constant at 17 km in travel surveys in 2004 and 2006. The congestion charge is adjusted for inflation and tax deductibility for company cars. Using the trip cost and traffic volume of 2005 as initial state, the price elasticity of the traffic volume across the cordon is computed. Table 3 shows that the elasticity for the non-exempt traffic increased steadily over the years after the introduction, from -0.87 at introduction in 2006 to -1.24 in 2014. The adjusted (for external factors) traffic volumes of non-exempt private traffic, excluding company cars and taxis (31% of the traffic across the cordon in 2006), and light and heavy trucks (18% across the cordon in 2006), are shown further down in Table 3. The calculations for private traffic result in the elasticity -1.57 in 2006, increasing to -2.49 in 2014.

Hence, in Stockholm there are no signs that the effect of charges is wearing off. On the contrary, it has increased slightly over time. This is consistent with the observation that there are more adaptation mechanisms available in the long term than short term. This result corresponds with that of Goodwin et al., (2004), who note that price impacts tend to increase over time as consumers have more options.

Table 3. Elasticities of the Stockholm system, 2006-14
Price level 2006

	2005 (without)	2006 (with)	2007 (with)	2008 (with)	2009 (with)	2010 (with)	2011 (with)	2012 (with)	2013 (with)	2014 (with)
Total effect on traffic volume from external factors (%)		0.51	2.70	3.15	4.61	3.59	3.93	3.50	6.13	8.51
Real average trip cost excluding the charge (EUR)	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55
Charged hours: Total										
Traffic volume across the cordon adjusted to 2005 levels wrt external factors (veh/h)	37 291	29 324	29 514	29 601	29 162	29 280	28 526	28 128	27 439	27 283
Non-exempt traffic volume across the cordon adjusted to 2005 levels wrt external factors (veh/h)	30 021	21 114	21 783	21 614	20 839	21 153	20 721	20 843	20 697	20 550
Real average charge (EUR)		1.28	1.06	1.04	1.06	1.03	0.99	0.94	0.92	0.91
Elasticity charged hours		-0.87	-0.93	-0.96	-1.05	-1.03	-1.13	-1.16	-1.21	-1.24
Charged hours: Private										
Traffic volume across the cordon adjusted to 2005 levels wrt external factors (veh/h) private	2 5140	13 287	12 875	12 458	11 082	11 678	11 368	11 906	11 956	11 747
Real average charge private (EUR)		1.28	1.06	1.04	1.06	1.03	0.99	0.94	0.92	0.91
Elasticity charged hours private		-1.57	-1.93	-2.06	-2.36	-2.26	-2.43	-2.38	-2.42	-2.49

Note: veh/h = vehicle/hour.

Table 4 shows how the corresponding elasticities for Gothenburg are calculated for the years 2013-15. There is no time series model to control for external factors for Gothenburg (like the one used for Stockholm). For this reason, I assume that the traffic increase due to other factors than congestion charges equals the national growth in car traffic. The first row of Table 4 shows how the national car traffic growth increased, most of which can be explained by GDP growth and a declining fuel price (Bastian et al., 2016; Bastian and Börjesson, 2015). The second row shows the trip cost excluding the congestion charge. For Gothenburg, the average trip length for cars crossing the cordon is 15 km, taken from the two-wave travel survey conducted before and after the introduction of charges (City of Gothenburg, 2013). The average trip length did not change significantly between the two survey waves. The Swedish tax authorities' driving cost was EUR 0.185/km in 2013. As for Stockholm, elasticities for private trips only are computed, i.e. passenger cars that are not owned by a legal person and taxis (which together has remained stable at around 21% since 2013) or light and heavy trucks (which has remained stable at around 22% since 2013).

Table 4. Elasticities of the Gothenburg system, 2013-15
Price level 2012

	2012 (without)	2013 (with)	2014 (with)	2015 (with)
Total effect on traffic volume from external factors (%)	-	-0.10	2.20	3.42
Real average trip cost excluding the charge (EUR)	2.78	2.78	2.78	2.78
Charged hours: total				
Traffic volume across the cordon adjusted to 2005 levels wrt external factors (veh/h)	52 597	46 855	47 581	47 525
Real average charge (EUR)	-	0.51	0.50	0.59
Elasticity charged hours	-	-0.69	-0.60	-0.52
Charged hours: private				
Traffic volume across the cordon adjusted to 2005 levels wrt external factors (veh/h)	29 717	26 473	27 169	26 852
Real average charge private (EUR)	-	0.59	0.58	0.69
Elasticity charged hours private	-	-1.18	-1.01	-0.85

Table 4 shows that the elasticity for the total traffic volume across the cordon in Gothenburg was -0.69 in 2013. This elasticity is slightly lower than the one observed in Stockholm in the first year, -0.87. The elasticity is also lower for Gothenburg for private trips.

There are different elasticity trends in the two cities. Whereas the Stockholm elasticity has steadily increased over the years from -0.87 at its introduction, the Gothenburg charging elasticity has declined from -0.69 in 2013 to -0.52 in 2015. The 2015 elasticity for Gothenburg is not directly comparable with the previous elasticities and the Stockholm elasticities up to 2011, because of the increases in the charging levels in January 2015. However, the 2014 elasticity is still lower than that observed for 2013.

The discrepancy between Stockholm and Gothenburg regarding the elasticity at the introduction, and the direction of the trends in the elasticities might be driven by differences in city structures and transport systems. Gothenburg is smaller and less dense than Stockholm, and most workplaces are located outside of the city centre. As a result, the public transport share is lower in Gothenburg. It means fewer ways to adapt in the long run.

Another possible reason for the diverging trends in the cities is that in Stockholm travel times for car trips have increased between 2006 and 2015 (Bastian and Börjesson, 2017) presumably due to a large number of construction works. This might be one reason for the seemingly increasing price elasticities over time.

The effect of the revisions are much smaller

In 2015, the Gothenburg charging levels were increased by 22% (from EUR 1.8 to 2.2) in the peak, but marginally in the off-peak (from EUR 0.8 to 0.9). In 2016, the Stockholm peak charge was increased by 75% (from EUR 2 to 3.5) but the off-peak charge was increased only marginally (from EUR 1 to 1.1).

This section starts by comparing the peak price elasticities observed when the charges were increased with those observed when they were first introduced.

Table 5 shows that in Gothenburg the peak elasticity was -0.16 when the charge was increased, compared to -0.53 at first introduction. The table also shows that in Stockholm, the peak elasticity was -0.28 when the charge was increased, compared to -0.67 at first introduction.

The elasticities computed in Table 5 differ from those computed earlier in this section in the sense that the initial state is also charged. For Gothenburg, Table 5 compares September-December 2015 traffic volumes and trip costs (including the cost of the charge after increase) with September-December 2014 traffic volumes and trip costs (including the cost of the charge before increase). For Stockholm, the table compares the March 2016 traffic volumes and trip costs (including the cost of the charge after increase) with the October 2015 traffic volumes and trip costs (including the cost of the charge before increase). In Stockholm, I choose to compare March 2016 with October 2015 (and not March 2015 with March 2016 or October 2015 with October 2016) because of substantial changes in the transport system of Stockholm before October 2015 and after March 2016. However, from historic data, it is clear that March and October have similar traffic levels in Stockholm. Furthermore, I do not account for general traffic growth in Stockholm due to the short time span of six months between the measurements.

Table 5. Peak price elasticities of increase charges

	Stockholm	Gothenburg
Traffic volume across the cordon in peak without charge increase (veh/h) ⁹	30 898	56 609
Traffic volume across the cordon in peak with charge increase (veh/h)	29 315	56 258
Real average trip cost excluding the charge (EUR)	3.15	2.78
Real average charge (EUR) without charge increase	1.37	0.63
Real average charge (EUR) with charge increase	2.31	0.77
Peak elasticity revised peak charge	-0.28	-0.16
Peak elasticity first introduction	-0.67	-0.53

For Stockholm, the analysis of the increase can be further deepened, with regard to different types of vehicles (private passenger cars, company cars, taxis/buses/emergency vehicles and trucks). The 2015/16 data from the Stockholm system is more detailed in terms of vehicle types than the data from the Gothenburg and the older Stockholm data. In this deeper analysis, the Stockholm system extension to encompass the Essinge bypass (E4/E20) is also included.

Before 2016, traffic between the northern and southern part of Stockholm could avoid the charges by using the Essinge bypass. However, during the years 2005-07, when the charges were introduced, abolished and then re-introduced, the traffic volume on the Essinge bypass remained unchanged, indicating that the substitution effect is small. For this reason, I assume here that the effect of the introduction of the charges on the bypass and the effect of the increased peak charging levels on the original cordon are independent of each other.

The elasticities are computed based on the input shown in Table 6. For trips on the Essinge Bypass I use the average car trip length of 32 km between the south and north of Stockholm, taken from the 2015 travel survey (Stockholm County Council, 2016), to compute the travel cost excluding the congestion charge.

The elasticities on the bypass are substantially lower than when the original cordon was first introduced, but also lower than when the charging levels were increased on the original cordon. Lower price elasticity on the bypass was also forecast from model simulations due to fewer substitutes for cars priced off the road.

The low elasticity for the total traffic on the bypass is partly an effect of increases in trucks (+5 %) and company cars (+10 %) on the bypass. On the original cordon, trucks decrease and the increase in company cars is lower. A possible reason for the larger increase of truck and company cars on the Essinge bypass is that travel times have reduced most there. The effect on travel times of the 2016 revisions were measured on a number of road segments in the transport system. The overall result shows that the travel times have reduced primarily in the bypass, by 40-50% on the road segments where travel times have reduced most (Trafikverket, 2017). In the rest of the network, the travel time reduction seems to be too small to be noticed by the travellers, partly due to some major road construction works in central Stockholm. The travel time reduction explains the seemingly positive price elasticity (which is not micro-economically consistent) for trucks and company cars on the bypass: they value the travel time gains higher than the charge. The number of taxis, buses and emergency vehicles is not included in the table but remained unchanged (approximately 4% of all vehicles on the bypass and 11% on the original cordon).

The finding that professional traffic (company cars used for business trips, trucks, taxis, buses and emergency vehicles) increases or has low price elasticity is intended by the charges: more valuable traffic, with a higher willingness to pay, should be prioritised. Now, a relevant issue from an equity and efficiency perspective is how many of the crossings made by the company cars are in fact private trips (including commuting).

Company cars make up 37% (Stockholm) and 21% (Gothenburg) of all passenger cars across the cordon (corresponding to 24% and 14%, respectively, of the total traffic volume across the cordon). From travel surveys, it is estimated that 20% (Stockholm) and 16% (Gothenburg) of all passenger car trips passing the cordon are made by drivers having access to a company car in the household.¹⁰ Some of these may still be business trips. However, in the Netherlands the company cars are used for business trips only 22% of the time (Gutiérrez-i-Puigarnau and Van Ommeren, 2011). This is also indicated from my data: First, less than 10% of the company cars that cross the cordon in Stockholm do that more than twice a day. Moreover, the time-of-day volume profile for company cars is similar to the profile of private passenger cars, with distinct peaks indicating commuting (44% charged passages are made in the peak, by company cars as well as by private passenger cars).

Table 6. Elasticities for the increase and the introduction on Essinge bypass
Price level 2015

	The original cordon	Essinge bypass (E4/E20)
Real average trip cost excluding the charge (EUR)	3.15	5.92
Traffic volume in peak 2015 (veh/h)	30 898	9 245
Traffic volume in peak 2016 (veh/h)	29 315	8 816
Change in traffic volume, peak	-5%	-5%
Real average charge (EUR) 2015, Peak, total traffic	1.37	-
Real average charge (EUR) 2016, Peak, total traffic	2.31	2.11
Elasticity peak total	-0,28	-0,16
Traffic volume in peak 2015, private (veh/h)	13 570	4 686
Traffic volume in peak 2016 private (veh/h)	11 878	3 990
Change in peak traffic volume, private	-12%	-15%
Real average charge (EUR) 2015, peak, private	1.79	-
Real average charge (EUR) 2016, peak, private	3.07	2.65
Elasticity peak private	-0,57	-0,44
Traffic volume in peak 2015, trucks (veh/h)	4 914	1 719
Traffic volume in peak 2016 trucks (veh/h)	4 632	1 811
Change in peak traffic volume, trucks	-6%	5%
Real average charge (EUR) 2015, peak, trucks	1.79	-
Real average charge (EUR) 2016, peak, trucks	3.07	2.65
Elasticity peak trucks	-0,25	0,14
Traffic volume in peak 2015, company car (veh/h)	7 843	1 790
Traffic volume in peak 2016 company car (veh/h)	8 175	1 977
Change in peak traffic volume, company car	4%	10%
Real average charge (EUR) 2015, peak, company car	0.00	0.00
Real average charge (EUR) 2016, peak, company car	0.00	0.00
Elasticity peak company car	-	-

So, to summarise, in Stockholm and Gothenburg, the elasticity of the increase of the charging levels was much lower than when the systems were first introduced. Moreover, the elasticity observed on the bypass, when the Stockholm system was extended, was even lower than the elasticity of the increased charging levels. This is consistent with results from Singapore (Xie and Olszewski, (2011)), but in Stockholm the difference in elasticity between the introduction and the increase is substantially larger.

The most likely reason for the lower price-elasticity is that the most price-sensitive car users (and most flexible in terms of mode, destination and time of day) are already priced off the road at its first introduction and are no longer on the road when charges are later increased. Hence, the drivers that

found it least costly to adapt had already done so prior to the increase. A second explanation could be transaction costs. Finkelstein (2009) argues that drivers pay less attention to an electronic pricing system than to manual toll collection. However, the transaction costs in the Swedish systems are small and reduced over the first five years,¹¹ without any traffic increases. A third possible reason for the lower elasticities is a zero-price effect, referring to the phenomenon that decisions concerning free goods differ from the decisions concerning priced goods (Shampanier et al., 2007).

Public and political support depend on different factors

Political support depends on power over revenue

Before congestion charges were introduced in Stockholm in 2006, all the political parties (except the Green Party) were against them in Stockholm and Gothenburg. This has changed since the introduction of the Stockholm charges, to the extent that all established parties in Stockholm and Gothenburg are now in favour of the charges. The extension of the systems and the (past and upcoming) increases in the charging level are supported by broad agreement in the city councils of both cities. This shift has been driven by the role that the revenues came to play in the negotiations for national grants for transport investments.

Prior to the implementation of the Stockholm charges, the decision makers at the local and regional level of all parties were greatly concerned that Stockholm would receive fewer national infrastructure grants if they introduced congestion charges. They feared that Stockholm would be forced to use the revenues from the congestion charges and thereby miss out on national grants. This issue was solved by an agreement between the national government and the region settled in 2007. Stockholm would receive a major transport road investment package, 50% funded by the revenues and 50% by the national government and the revenues were earmarked for a new bypass. This was a turning point for the political support. It led the decision makers in the Gothenburg region to seek a similar deal, resulting in a broad political coalition in the Gothenburg City Council to support the “West Swedish package”, partly funded by congestion charges (28 October, 2009). The largest investment in this package is the West Link (EUR 2.0 billion), which is an 8-km-long rail link including a 6-km-long tunnel under central Gothenburg with very low value for money (BCR 0.45 (Mellin et al., 2011)). The co-financing of the West Swedish package is the reason behind the increases in the charging levels in Gothenburg 2015 (it was not justified by congestion).

In recent years, the political drivers for the congestion charges in Stockholm have become more similar to those in Gothenburg. The revenue generated from the extensions of the charging system and the increased charging levels are earmarked for co-financing of new metro investments (making up 46% of the total cost), leveraged with funding from the municipalities of the Stockholm region (27%), Stockholm County (3%) and the national government (24%) (The Stockholm Agreement, 2013). The value for money of the metro investment is, just like the West Link, very low: BCR 0.3 (The Stockholm Agreement, 2013).

Moreover, the charging levels will be increased again in 2020, to co-finance further rail infrastructure investment,¹² with low value for money.

The model-based study used to design the revision in system/charging levels shows that the current charge level is probably not that far from the optimal charge in Stockholm and Gothenburg. Moreover, the parking charge is in many cases lower than optimal, and for this reason higher charging levels might be a good idea. The key problem is that the revenue is earmarked for co-financing infrastructure with very low value for money. The government borrows money to pay for the investments and repays the loans using the revenue from the congestion charges, such that they are tied up decades ahead. This is a paradigm shift in Sweden's infrastructure planning, where the government does not in other cases borrow to finance infrastructure investment, which reduces the pressure to realise bad investments.

Public support has decreased after revisions

This section shows the long-term trends in public support in the two cities, discussing the differences, similarities and possible drivers of these trends. In Gothenburg, support for the charges has always been lower than in Stockholm, possibly due to higher car dependence in Gothenburg: the public transport market share for trips across the cordon in Stockholm is which is approximately 80%, the corresponding share for Gothenburg is 25%. In both cities, the public support fell as the introduction approached and once the charges were introduced, the support increased again (see Figure 2 and 3). Börjesson et al. (2016) find that the change in the support once the charges are introduced is due to a status quo bias.

Figure 2 shows how public support for the charges has developed in Stockholm. In 2004, over 45% of the citizens of the city of Stockholm stated that they would vote in favour of congestion charges in a referendum. The support fell, however, as the introduction approached and just before the introduction of the charges it had fallen below 40%. Once the charges were introduced, the support increased again and in the referendum in the autumn of 2006, 53% of the citizens of the city of Stockholm voted to keep the charges (excluding blank votes). Up until 2013, the support for the charges gradually increased to over 70%. In the poll in 2013, 47% of the citizens of the city of Stockholm were positive to introducing congestion charges on the Essinge bypass (E4/E20) and 53% were against.

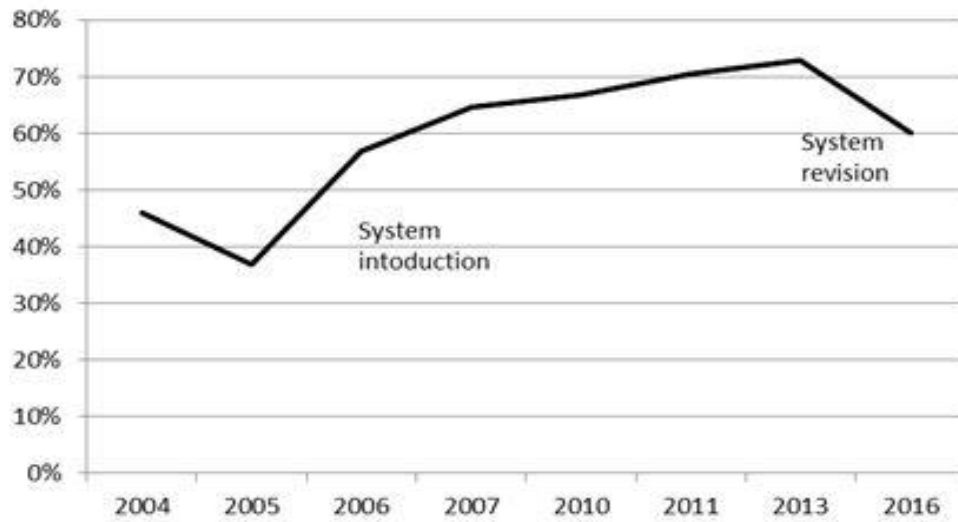
When the charges were revised in 2016 the media coverage was almost non-existent. However, the support for the charges dropped in 2016, for the first time since they were introduced. The support declined to 60%, which is almost down to the 2006 level. The support for the charges on the Essinge bypass, however, increased from 47% to 53% in favour (following the familiar pattern that supports the charges increases once they are introduced).

The decline in support could be caused by the extension of the system to the bypass (which still has lower support than the original system), the substantial peak charge increase, or the small effect it had on travel times (the effects are so small that the travellers cannot have noticed them, except for some segments on the bypass). The use of and focus on the revenues for infrastructure that few citizens will benefit from, framing the charges as a tax instrument, might also contribute to the decline in support.

In Gothenburg, only just over 30% supported congestion charges in 2011, and this support declined to 27% just before the charges were introduced (see Figure 3). Just as in Stockholm, support increased after the introduction, but the referendum in September 2014 still resulted in 55% voting for abolishing the charges (the referendum was only consulting and was not followed by the decision makers because the revenue is used for funding a large infrastructure investment package). In a poll in the autumn of 2014,

just after the referendum, 51% stated that they supported the charges.¹³ After the increases in the charging levels, support for the charges fell (as in Stockholm), and since then it has continued to decline.

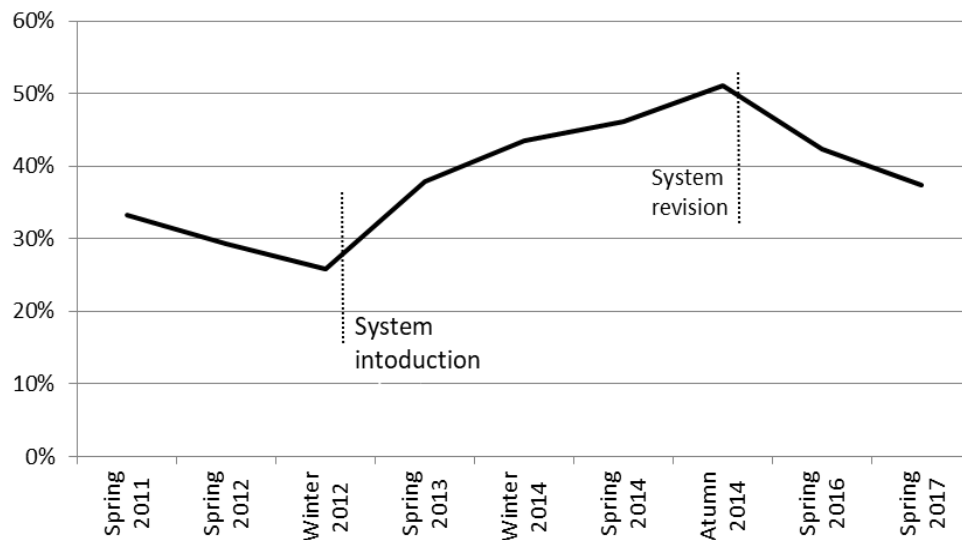
Figure 2. Share of respondents supportive of a hypothetical referendum of congestion charges in Stockholm



Note: The question was formulated as: "How would you vote in a referendum about the Stockholm congestion charges?"

Source: Repeated surveys conducted by the City of Stockholm

Figure 3. Share of respondents who state that they are positive or very positive to the congestion charges



Note: The question is formulated as: "How positive or negative are you to the Congestion Charges –as part of the financing the infrastructure package?"

Source: Repeated surveys conducted by the National Transport Administration.

The decline in support in Stockholm and Gothenburg after system revisions shows that the success story of Stockholm should not be taken for granted. The Stockholm and Gothenburg cases indicate that the spending of the revenue does not necessarily help build support for congestion charges (if the spending generates low benefits) as suggested by previous literature (Goodwin, 1989; Jones, 1991; King et al., 2007). The small effect on travel times might (due to low congestion initially and even more so when the charge was increased) also contribute to the low and declining public support. It is likely to add to the impression that the congestion charges are another tax instrument rather than a green policy or a traffic management instrument (the latter two arguments are fundamental for gaining support for congestion charges in several countries (Börjesson et al., 2015)). The focus on the revenues when the charging levels were (and will be) increased might also contribute to the impression that these levels can be increased arbitrarily once they are introduced, and thereby induce distrust among the citizens.

Conclusion

Congestion charges work, instantly and over time, and can be recommended for implementation in congested metropolitan areas. It is almost 12 years since congestion charges were introduced in Stockholm. They were extremely controversial ten years ago but have become increasingly accepted among decision makers in Sweden. Many view the charges as a policy to reduce congestion, but also to combat climate change, to finance new infrastructure, and to reduce local air pollution and noise. Key questions for the next decade are whether the charging system should be further extended, and what other cities can learn from the Swedish experiences.

The congestion charges have in many ways become a success story. They were initially effective in reducing traffic volumes and are socially beneficial in both Stockholm and Gothenburg. The ANPR systems technology has proven to work with high resilience. Moreover, the operating costs of the systems have declined substantially over time. There also seem to be a strong case for reducing not only congestion but also health-damaging emissions in large metropolitan areas. Hence extending the system by a differentiation of the charging levels such that vehicles emitting more health-damaging pollutants pay higher charges might be a good idea.

However, whereas the price elasticity has increased over time in Stockholm, it is declining in Gothenburg. The discrepancy between Stockholm and Gothenburg regarding the direction of the trends in the elasticities might be an effect of differences in city structures and transport systems. Gothenburg is smaller and less dense compared to Stockholm, with most workplaces located outside the city centre. For these reasons Gothenburg has substantially lower public transport shares and congestion is located on the highway hubs rather than around the city centre. Together this means fewer ways to adapt to the charges in the long term. Some drivers might even have tried public transport but switched back to car. Whether this experience is transferable to other cities is difficult to know, but it is at least a warning.

The behavioural effect of extensions and further increases in the charging levels is diminishing. This implies that the sum of money that is redistributed in relation to the welfare gain of a further increase in the charging levels or extension of the system is larger than when the systems were first introduced. The lower price elasticities observed after the increase in charging levels in Stockholm and Gothenburg also

indicate that dynamic price adjustments are not as effective as suggested from the experience in Singapore (Olszewski and Xie, 2005).

Moreover, public support is sensitive to system revisions. The gradual increase in public support after the charges were introduced and before it was revised, when over 70% supported the charges, and the positive referendum result are perhaps the most surprising and encouraging lessons of the Stockholm congestion charges. However, after the system revision in 2016 the public support fell for the first time. The story of Gothenburg also underscores that public support should by no means be taken for granted even after introduction of the charges: the decision makers have not been able to build long-term stable public support for the charges, possibly due to lower congestion levels and higher car dependence.

From a policy perspective a trial can therefore be recommended, and the policy maker can study how the public support develops and have a referendum before making the system permanent – but the problem is then to justify the investment of large resources in a system that might not survive after a trial. However, for cities like New York, where there are already tolls on the bridges that could be transformed to a congestion charging system, reducing the system investment cost substantially, a trial might be a good idea. Don't place a referendum just before the introduction of the system, at that time the support will dip. Since support declines with revisions, the strategy to start with a simple system with the objective to revise it over time cannot be recommended. It is better to keep the system design including charging levels constant over time. Because the effect of increased charging levels is limited, dynamic pricing might be less effective. Moreover, dynamic pricing reduces the control over the revenues, which might reduce political support more than expected.

In cities like Gothenburg, with low market share for public transport, and high car dependence among low-income inhabitants, there is also a high negative distribution effects from congestion charges. Currently, the negative effects also depend on how the revenue is spent.

These Swedish experiences demonstrate that the critical conditions for the support for the charges among decision makers are that the charges have been part of a bigger investment package deal. The political focus for congestion charges has increasingly shifted towards financing of large investments, and has come to favour the use of the revenue for large and prestigious transport investments with low value for money. This was not foreseen when the charges were first introduced. However, since the charges have become part of a large package, negotiated between many stakeholders, they cannot be modified as more facts become available (for instance, cost estimates or benefit calculations). Moreover, the revenue collected from future generations in decades ahead is tied up to repay the loans taken to finance investment packages, and these generations do not vote in the next general election. This increases the risk of the kind of principal-agent problems described by Flyvbjerg et al. (2009). Similar problems have been discussed in the context of the Norwegian road tolls, primarily used to finance a large package of infrastructure investments (Ieromonachou et al., 2006; Larsen and Ostmo, 2001). A potential reason for the low value for money is that stakeholders take only their own share of the cost of the package into account but not the total benefit.

It is unclear to what extent this conclusion is transferable to other countries with other governance systems; in London, for instance, the revenue is used mainly for buses. However, had the congestion charge not been so favourable for the cities of Stockholm and Gothenburg¹⁴ (because of prestigious mega investments leveraged with national infrastructure grants) it is likely that the charges would never have been introduced in the first place, because of political resistance on the city level. Such resistance is common in many countries because the political support depends greatly on the power over the revenues, which in the Swedish case seems to have had some undesirable impact on the investment planning.

Notes

- 1 Based on discussion at the 2017 Roundtable on Social Impacts of Time and Space-Based Road Pricing in Auckland, New Zealand.
- 2 Throughout the paper, the conversion rate of SEK 10 \approx EUR 1 is used.
- 3 Rat-running is the practice by motorists of using residential side streets or any unintended short cut such as a parking lot or delivery service lane instead of the intended main road in urban or suburban areas
- 4 Decision by the Swedish Administrative Court 2008-10-22 case number 4006-08.
- 5 Data from the system shows that 35% of passages across the initial Stockholm cordon (before and after 2016) in the off-peak are made by vehicles that also travel in the peak. The corresponding number for company cars is 54% and for trucks 50%. Moreover, 39% of passages in the peak are made by vehicles that also travel in the off-peak. The corresponding number for company cars is 54% and for trucks 65%.
- 6 The total number of public transport trips in the charged OD-pairs increased 6%, from 211 000 to 224 000 (City of Gothenburg, 2013). According to Table 5 we have $\log(\text{cost with}/\text{cost without}) = \log((0.51+2.78)/2.78)=0.073$. Hence, the cross-price elasticity is $\log(223/211)/0.073=0.33$. However, the cross-elasticity is zero for other trips and higher for commuting trips.
- 7 <http://www.stockholmsforsoket.se/upload/Rapporter/Fakta%20och%20resultat%20stockholmsf%C3%B6rs%C3%B6ket%20aug%2006.pdf>
http://www.trafikverket.se/contentassets/2109d7678fa74783b431d595e23d9ab5/rapporter/rapport_forsta_aret_med_vastsvenska_paketet.pdf
- 8 Source: <https://www.transportstyrelsen.se/sv/Press/Kommentarer-och-fortydliganden/Vad-kostar-det-att-ta-ut-trangselskattinfrastrukturavgift-/>
https://www.transportstyrelsen.se/globalassets/global/om_oss/finansiering/arsredovisning/arsredovisning-2016.pdf
<https://www.transportstyrelsen.se/sv/vagtrafik/statistik-och-strada/Vag/trangselskatt11/>
- 9 In Stockholm, this refers to the average peak traffic flow across the cordon in October 2015 and in Gothenburg it is the average peak traffic flow across the cordon in Sept-Dec 2014.
- 10 According to the Gothenburg travel survey (City of Gothenburg, 2013), 8% of the citizens of Gothenburg have access to a company car in the household to be used for private trips. The respondents stating that they have access to a company car also stated that they pass the toll cordon twice as often as citizens having access to a private car (0.8 vs 0.4 times per day) (Börjesson et al., 2016). From this I conclude that company cars make up approximately 16% of all passenger cars crossing the cordon. According to a travel survey conducted in the Stockholm County in 2015 (Stockholm County Council, 2016) 10% of the citizens of Stockholm have access to a company car for private trips. Assuming that citizens having access to a company car pass the cordon twice as citizens with access to a private car (as in Gothenburg), I have that company cars make up approximately 20% of all passenger cars crossing the cordon in Stockholm.
- 11 During the trial in 2006, payment of the charge had to be made within fourteen days after passing the cordon and there was no invoice sent by mail. Payment could be made at specific shops (Pressbyrån and 7-eleven), via autogiro or bank transfer. Since 1 August 2008 a monthly invoice for the crossings during the previous month has been mailed to the owner (by ordinary mail or as an E-invoice direct to the Internet bank of the driver) of the vehicle and it must be paid within the next month.
- 12 Yet another metro line and a local train. Again these investments give low value for money.
- 13 It is unclear why the support in the referendum in autumn 2014 was lower than in the poll just after. One possibility is that the 22% of the respondents in the poll that were undecided had a stronger tendency to vote against. Another possibility is that citizens that are more positive to the charges have a higher response rate in the poll.
- 14 For instance, the City of Gothenburg carries only 4% of the total cost of the Agreement (0.125 out of EUR 3.4 billion).

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Long-Term Effects of the Swedish Congestion Charges

This paper summarises the state of research on the long-term effects of congestion charging in Stockholm and Gothenberg. Sweden's two largest cities introduced time-of-day dependent, cordon-based congestion charging systems in 2006 and 2013. Public support for congestion charging initially increased following the introduction, but then slightly declined after a revision of the systems. While travel demand in Stockholm has become more price sensitive over time, the reverse happened in Gothenburg. The study examines the reasons behind these findings and discusses policy implications.

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