# The Stockholm congestion charges – four years on Effects, acceptability and lessons learnt

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### Abstract

Congestion charges were introduced in Stockholm in 2006, first as a trial followed by a referendum, then permanently from 2007. This paper discusses what conclusions can be drawn from the first four years of operation. We show that the traffic reduction caused by the charges has increased over time, once external factors are controlled for. Alternative-fuel vehicles were exempt from the charges through 2009, and we show that this substantially increased the sales of such vehicles. We discuss public and political acceptability, synthesizing recent research and Swedish experience. We conclude that objective and subjective effects on the traffic system, as well as general environmental and political attitudes, formed the basis of the strong public support, while institutional reforms and resolution of power issues were necessary to gain political support. Finally, we briefly discuss implications for the transport planning process in general.

## Introduction

Congestion pricing has been long advocated by transport economists and traffic planners as an efficient means to reduce road congestion. Despite growing problems with urban congestion and urban air quality, and despite a consensus that investments in roads or public transit will not be sufficient to tackle these problems, cities have been reluctant to introduce congestion pricing.

In recent years, however, it seems that this is changing. London (2003), Stockholm (2006), Durham (2002), Milano (2008), Rome (2001) and Valletta (2007) have all introduced road user charges to combat congestion and/or environmental problems. The Netherlands, Copenhagen, Budapest, Gothenburg, Djakarta and San Francisco are all considering congestion charges or planning to introduce them. The soon ubiquitous “value pricing” roads in the US are another example of how congestion problems are now being tackled through pricing measures. New York, Manchester and Edinburgh have all tried to introduce congestion charges, and even if these attempts have been unsuccessful, it is a sign that congestion charges are being seriously considered to a greater extent than a decade ago.

The congestion charges in Stockholm have attracted enormous attention worldwide. Obviously, the opportunity to gauge the effects of congestion charges on traffic, congestion levels and travel behaviour has attracted great interest. Perhaps even more interesting is how the congestion charges survived a heated and complicated political and legal process, including a referendum initially forced through by those opposing the charges. The Stockholm charges went from “the most expensive way ever devised to commit political suicide” (to quote the then-secret feelings expressed by the Head of the Congestion Charging Office[[1]](#footnote-1)) to something that the initially hostile media declared to be a “success story” (e.g. Dagens Nyheter, June 22, 2006).

The Stockholm charges were introduced four years ago in January 2006. The aim of this paper is to explore the effects of the charges in the longer term – not only the effects on traffic and congestion, but also effects on public and political acceptability and to some extent effects on the national infrastructure planning process.

There has been some apprehension that the effects of the charges will attenuate over time – either because drivers “get used to charges” and hence do not react to them anymore, or because the freed-up road space will be filled again by new groups of drivers, so that the congestion situation will be the same as before the charges. This is the topic of section 2, where we try to explore the issue of the long-term effect of the charges on traffic volumes.

Section 3 investigates the significance of the clean car exemption and the importance of different incentives for the sales of clean cars.

Section 4 is devoted to public and political acceptability. We draw from a number of sources to explain and discuss the current opinion on congestion charges, and the political context of the charges. We also discuss how the possibility of introducing road user charges has affected the national infrastructure planning process.

## An overview of the Stockholm congestion charging system

The Stockholm congestion charging system consists of a simple toll cordon around the inner city, thereby reducing traffic through the bottlenecks located at the arterials leading into the inner city. The cost of passing the cordon on weekdays is € 2[[2]](#footnote-2) during peak hours (7:30-8:30, 16:00-17:30), € 1.5 during the shoulders of the peaks (30 minutes before and after peak period) and € 1 during the rest of the period 6.30-18.30. The charge is levied in both directions, implying that a return trip during peak hours costs € 4. The maximum fee per day is € 6.

The system was introduced on a trial basis during the period 3 January – 31 July 2006. The trial period was followed by referendums in the City of Stockholm and in about half of the neighbouring municipalities, originally pushed through by parties opposed to the congestion charges. The referendum in the City of Stockholm itself resulted in a majority for keeping the charges, but based on the total number of votes in the County of Stockholm the majority of the voters were against the charges. However, adding all the votes in the County produces a result that is negatively biased compared to the overall public opinion in the County of Stockholm, because not all municipalities arranged a referendum. The public opinion in the municipalities that arranged a referendum was in general more against charges than the public opinion in the entire County. In the end, the new Liberal-Conservative government decided to reintroduce the congestion charges, earmarking the revenues for road investments but as part of a more comprehensive, partially government-funded transport investment package including both road and transit investments. The congestion charges were reintroduced in August 2007.

The charging trial has been described in detail elsewhere. A description of the effects can be found in Eliasson et al. (2009) and Eliasson (2008), where the latter also discusses the main lessons from the trial in terms of design, effects, acceptability and political process. A detailed account of the political process can be found in Gullberg and Isaksson (2009), and experiences from the design and evaluation processes are described in Eliasson (2009a). Isaksson and Richardsson (2009) analyse the strategy to create legitimacy for the charges, while Gudmundsson et al. (2009) examine how decision support systems were used. Eliasson (2009b) provides a cost-benefit analysis of the congestion charges, based on effects measured during the trial.

## LONG-TERM ADAPTATION effects

The charges had a substantial effect on traffic volumes, and drivers have adopted many different adaptation strategies. In this chapter we explore the extent to which the behavioural adaptation has changed over time.

### Traffic volumes across cordon

Figure 1 shows the average number of passages across the cordon per weekday (6 am to 7 pm) for each month from January 2005 through September 2010. Corresponding numbers are presented in Table 1.

For each year, Figure 1 exhibits a systematic seasonal variation, with volumes increasing throughout spring, showing a distinct minimum in July and August (summer holidays) and stable volumes during the rest of the year.

Figure 1: Average number of passages across cordon (weekdays 6-19). 2005-2010[[3]](#footnote-3)

Table 1: Reduction in traffic volumes over cordon (weekdays 6-19) compared to reference (2005)

*Figures in italics represent period without charging (Aug 2006 – Jul 2007)*

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Compared to 2005** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul[[4]](#footnote-4)** | ***Aug*** | ***Sep*** | ***Oct*** | ***Nov*** | ***Dec*** |
| **2006** | **-28%** | **-23%** | **-22%** | **-21%** | **-20%** | **-21%** | **-24%** | *-11%* | *-9%* | *-6%* | *-9%* | *-7%* |
| **2007** | *-9%* | *-8%* | *-8%* | *-11%* | *-8%* | *-18%5* | -26%[[5]](#footnote-5) | **-21%** | **-20%** | **-17%** | **-18%** | **-17%** |
| **2008** | **-19%** | **-17%** | **-17%** | **-16%** | **-19%** | **-22%** | - | **-17%** | **-19%** | **-16%** | **-19%** | **-17%** |
| **2009** | **-19%** | **-18%** | **-16%** | **-16%** | **-19%** | **-24%** | - | **-17%** | **-18%** | **-15%** | **-17%** | **-20%** |

***The trial: Immediate reaction, slightly diminishing over time***

Figure 1 indicates clearly that the charges had a substantial effect on car driver behaviour from the first day of introduction in January 2006. This effect, as reflected by relative difference to the reference level (2005), was -28 % in January.

During the following months, volumes across the cordon increased successively – from just over 300 000 per day in January, to almost 400 000 per day in May. Some observers in the media and the general public saw this increase (large enough to be noticed by the naked eye) as a sign that the charges were successively losing their effectiveness. To the informed analyst, however, it is evident that the increase was mainly due to seasonal variation, and that the pattern exhibited resembles the reference figure for 2005. Nevertheless, the figures indicate that road users overreacted initially (with an estimated effect of -28 % in January, -24 % in February and -23 % in March), but successively found more stable adaptation strategies (-22 % in April, May and June).

The adaptation strategies were different for different trip purposes. 24 % of commuting trips across the cordon disappeared; nearly all of these switched to transit – only 1 % switched route to avoid the cordon. 22 % of discretionary trips across the cordon disappeared; here, the main adaptation strategies seem to have been changing destinations and decreasing trip frequencies. Commercial traffic (deliveries, business trips, freight traffic etc.), decreased by approximately 15 %, adapting by switching route or by trip chaining (Eliasson, 2008; see also Franklin et al., 2009).

***The in-between period: Traffic increased, but some effects of charging remained***

From 1 August 2006, charges were no longer in effect. As expected, this had a direct and observable effect on traffic volumes across the cordon, which immediately rebounded to levels substantially higher than during the charging trial. However, the charging scheme continued to affect road user behaviour even after the trial had ended; from August 2006 to August 2007, i.e. between the end of the trial and the reintroduction of the charges, traffic volumes remained 5-10 %[[6]](#footnote-6) lower than in 2005.

Why did some drivers not return to their old habits in the period when no charges were levied? Other factors, such as fuel prices, changed too little to cause such a relatively large traffic decrease. Apparently, some car users developed new travel habits during the trial – habits persisting even after the charges were abolished. It is impossible to certify the cause-effect relationship underpinning our observation of a residual traffic decrease. One hypothesis is, however, that some drivers were pressed by the charges to search for travel alternatives, and found such alternatives that were indeed more suitable for them, once they were tested. Another hypothesis is that some drivers were forced to invest in alternative travel options (e.g. buying a motorcycle), which could not be changed back without new transaction costs. (Further discussions of “hysteresis” effects can be found in Goodwin (1977) and Dargay (1993).)

***Permanent charges: Immediate effects, successive volume increase due to external factors***

The charges were reintroduced in August 2007. Compared to the old reference (2005), the introduction of permanent charges had the same effect on traffic volumes as charging had had during the trial: in August 2007 there were 21 % fewer passages across the cordon (during charging hours) than in August 2005.

During the first year of permanent charges, volumes over the cordon increased. In the end of 2008, the relative difference compared to the 2005 level was -17 %, apparently substantially smaller than the -22 % at which relative difference had stabilized at the end of the trial. There is a tendency for volumes to continue to increase even in 2009. For most months, however, volumes in 2009 were about 1 % larger than for the corresponding month in 2008.

### Have the effects attenuated over time?

The observed successive increase of cordon volumes described in the previous section can at first sight be interpreted as indicating that the effects of the charges attenuate over time, in other words that the price elasticity of traffic decreases over time. However, this interpretation does not take into account that various other factors influencing traffic volumes have changed over time. In this section we will compare the long-term and short-term effects of charging, taking these external factors into consideration. Note, however, that as time passes, it becomes increasingly difficult to separate the effects of the congestion charges from other external factors.

There are two reasons why the long-term effects could be *smaller* than the short-term effects. First, there is the “acclimatization” effect: after a while, people might get used to the charge and consider it less important when making their travel choices. This effect could be especially important if it is, at first, a little difficult to pay the charge – and the extra “cost” of actually making the payment might decrease over time. Second, the freed-up road space may induce new traffic – travellers with high values of time, or travellers making car trips not crossing the cordon.

There are also a number of reasons why the long-term effects could be *larger* than the short-term effects. There are more possibilities to adjust travel behaviour in the long run. Over time, people continually reorganize their lives, relocate place of residence or work, become familiar with new destinations or change other habits, and in this process they will take the permanent charges into account. The fact that the charges were first implemented as a “trial” might also have implied smaller behavioural effects in the short run because travellers decided to wait it out.

To calculate the real long-term effect of charging, we assess what the traffic volumes would have been in 2009 without charges. We also take into account that the average charge in real terms has changed over time.

To assess the traffic volumes in 2009 in a situation without charges, we use the traffic volumes from 2005 (before charges) and add the traffic volumes arising from external factors, such as population growth and fuel price. As part of the Stockholm trial evaluation, a time series model was estimated specifically from data on traffic flow across the cordon 1973-2005 (Eliasson, 2009b). The time series analysis reveals the impact on traffic from various external factors, which is summarized in Table 2. The fuel price elasticity -0.3 is well established in the literature (see for instance Goodwin et al., 2004). The same table shows the development of these external factors in Stockholm County between the years 2005 and 2008. Transferring these numbers to effects on traffic volumes in the period 2005-2009 gives that the external factors have jointly contributed to a 5.6 % increase in traffic volumes crossing the cordon. If the effect of the charges had been constant, we would thus have expected the decrease in traffic volumes of 22% to have been reduced by 5.6 percentage units.

The actual reduction of traffic volumes from 2005 (before the charges) to 2009 (with charges) was 18 % (yearly average). To deduce the effect of the charges in 2009, we control traffic increase arising from the external factors 2005-2009 by adding 5.6%. Hence, charging effectively reduces the traffic through the inner-city cordon by 23.6 %, which is slightly more than the reduction during the trial.

Table 2: Impact on the traffic from external factors in Stockholm County, 2005-2008.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Development of external factors in Stockholm county, 2005-2008.** | | | | | | |
| *Compared to 2005 levels* | *2006* | | *2007* | | *2008* | *2009* |
| Number of people in employment | 1.6% | | 4.0% | | 7.4% | 8.1% |
| Fuel price (€/litre, 95 oct) | 2.9% | | 5.3% | | 5.5% | 1.4% |
| Private cars per employed person | 0.0% | | -1.3% | | -2.6% | -1.6% |
|  |  | |  | |  |  |
| **Impact on the traffic from external factors in Stockholm county, 2005-2008.** | | | | | | |
| *Compared to 2005 levels* | | *2006* | | *2007* | *2008* | *2009* |
| Number of people in employment | | 1.4% | | 3.4% | 6.3% | 6.9% |
| Fuel price 95 oct, €/litre | | -0.9% | | -1.6% | -1.6% | -0.4% |
| Private cars per employed person | | 0.0% | | -0.7% | -1.3% | -0.8% |
| **Sum** | | **0.5%** | | **1.1%** | **3.2%** | **5.6%** |
|  | |  | |  |  |  |
| **Elasticities** | |  | |  |  |  |
| Number of people in employment | | 0.85 | |  |  |  |
| Fuel price (€/litre, 95 oct) | | -0.3 | |  |  |  |
| Private cars per employed person | | 0.5 | |  |  |  |

The real average charge has changed over time for three reasons. First, inflation means that the charge has decreased by 16% in real terms since 2006. Second, the charges are now deductible for commuters provided certain requirements are met[[7]](#footnote-7), which was not the case during the trial in 2006. This applies to approximately 8 % of all trips, according to a travel survey (RES2005-2006). The tax deductibility represents a 60 % reduction of the charges. Third, regulations for company car costs have been changed. A “company car” denotes a company-owned car used by an employee for both work-related and private purposes. Company cars, which constitute 17 % of all vehicles crossing the charging cordon, receive at least a 60 % reduction of the congestion charge, since the drivers are now allowed to pay the charge from their gross salary. About 20 % of all company cars pay no charge at all. During the trial, no such discount was received.

The share of exempt vehicles has remained constant, but applied to more cost-sensitive traffic in 2009 than in 2006. Passages with taxis, which were exempt from congestion charge during the trial, were no longer exempt in 2009. Passages of alternative fuel vehicles, which were exempt throughout 2009[[8]](#footnote-8), have increased such that the share of exempt traffic has remained constant. The proportion of passages made by alternative fuel vehicles has increased from 3% during the trial to 14% in 2009. Taxis are, on average, presumbly less price-insensitive than alternative fuel vehicles, implying that the non-exempt traffic has become less price-sensitive.

Although the average price sensitivity for alternative fuel vehicles is higher than for taxis, they are less price-sensitive than average traffic. Most alternative fuel vehicles are taxis (2.6% out of 14%), company cars or cars in commercial traffic (8.2% out of 14%). Moreover, for company cars the tax-deduction regulation would apply if alternative fuel vehicles had not been exempt. The increased share of alternative fuel vehicles has therefore only contributed to a minor increase in traffic volumes across the cordon.

The effects on the average charge due to the changes in taxation and regulation discussed above are summarized in Table 3. Also considering changes in traffic volumes since 2006, we are able to compute the price elasticity on traffic volumes across the cordon in the same table.

The median length of trips crossing the cordon is 13 km[[9]](#footnote-9), according to the travel survey carried out during the trial. During the trial, the average congestion charge was EUR 1.28 per passage, implying a price elasticity of approximately -0.72 on traffic volumes across the cordon. If commercial traffic was completely price-insensitive, the price elasticity of the private traffic would be -1.32. Since commercial traffic was found to adapt (see section “The trial: Immediate reaction, slightly diminishing over time”) we know that this traffic is price- insensitive to some extent, implying that the elasticity for private trips lies between -0.72 and -1.32. In 2009, the corresponding elasticities are higher: -0.87 for all charged trips and between -0.87 and -1.83 for charged private trips.

The price elasticity has increased on average by 14 percent, from -0.72 to –0.87. According to the above discussion on exempt traffic, the non-exempt traffic comprised a less price-insensitive segment of drivers in 2009 than in 2005. This means that within the segment of non-exempt private drivers, the elasticity has increased by more than 14 percent­. Note also that these elasticities are not comparable with cost elasticity for driving (which is about twice the fuel price elasticity, -0.6). The charge elasticity of traffic across the cordon is higher, since it includes route and destination choices in addition to frequency and mode choices.

In summary, we find that the effects of the charges have increased over time. In other words, long-term effects are larger than the short-term effects. This is partially due to the “acclimatization” effects already fading out during the trial: the percentage decrease in traffic across the cordon stayed virtually unchanged after the first one or two months. Although these effects may be small in relation to the immediate possibilities of changing mode or route, our evidence supports the hypothesis that the possibilities for adaptation in other ways increase over time. This result is in correspondence with that of Goodwin et al. (2004), who note that price impacts tend to increase over time as consumers have more options (related to increases in real incomes, automobile ownership, and perhaps telecommunications that can substitute for physical travel).

Table 3: Cost elasticity calculations[[10]](#footnote-10)

|  |  |  |
| --- | --- | --- |
|  | ***2006*** | ***2009*** |
| Median distance [km] | 13 | 13 |
| Marginal driving cost [€/km] | 15 | 15 |
| Median trip cost, price level 2006 | 19.5 | 18.5 |
| Average percentage discount per passage because of deductibility of costs for commuting, charge reduction for company cars and inflation | 0 | 0.16 |
| Average charge per passage in price level of 2006 [€] (changed tax-regulations in 2009 are taken into account) | 12.8 | 10.8 |
| Trip cost for charged trips [€] | 32.3 | 29.3 |
| Charges in percent of total trip cost | 1.66 | 1.58 |
| Volume decrease across cordon (In the *2006* column, the traffic volume is compared the 2005 level. In the *2009* column, the traffic volume is compared to the hypothetical traffic flows without charges in 2009.) | 0.78 | 0.76 |
| Share of exempt traffic | 0.28 | 0.28 |
| Volume decrease across cordon of charged passages | 0.69 | 0.67 |
| Share of heavy goods vehicles | 0.18 | 0.18 |
| Business trips, non-exempt | 0.09 | 0.06 |
| Taxi, non-exempt | 0.00 | 0.06 |
| Commercial traffic + exemptions | 0.55 | 0.58 |
| Volume decrease across cordon of private charged passages | 0.51 | 0.43 |
| Elasticity, all charged traffic | -0.72 | -0.87 |
| Elasticity of private trips | -1.32 | -1.83 |

### Traffic volumes on other links (not crossing the cordon)

Next, we discuss how the traffic volumes have developed inside the cordon, on important bypasses and links outside the cordon. For the inner city, a key issue is whether we can identify any trend increase in traffic volumes, indicating that the road space freed-up by the charges generates new traffic.

The traffic volumes in the inner city were 8%-9% during the trial (depending on type of street) compared to the levels before the trial. Traffic volumes have remained stable since the charges were introduced.

Traffic between the northern and southern part of Stockholm can avoid the charges by using the bypass E4/E20 west of the inner city. Some of this traffic will also use the southern relief road, Södra länken. These relief roads were already congested before the implementation of congestion charges and there were concerns that congestion would become even more severe when the charges were introduced. However, the traffic volumes have remained relatively unaffected by the charges.

Traffic on relief roads, bypass E4/E20 and Södra länken, have only increased by approximately 5 percent since 2005, which can be explained by an increase in employed inhabitants (assuming the same traffic increase applying to traffic crossing the cordon calculated in the previous section). Södra länken shows a similar pattern, although the percentage increase is somewhat larger. The higher increase is largely due to higher population growth in the relevant catchment area than in the Stockholm County and to ramp-up since the link opened in 2004. However, traffic volumes on Södra länken fell in 2008 (down by 4.6 percent, compared to 2007), for the first time since the road opened in late 2004.

Figure 2 visualizes the trend increases in traffic volume on bypass E4/E20 and Södra länken. Interestingly, the figure does not indicate when the congestion charging system was introduced (January 2006), turned off (August 2006), and then re-introduced (August 2007), which confirms the conclusion that the charges have no large impact on the congestion levels on the orbital roads.

Figure 2: Traffic volumes from 2004 to 2008 on bypass E4/E20 and Södra länken, free of charge.

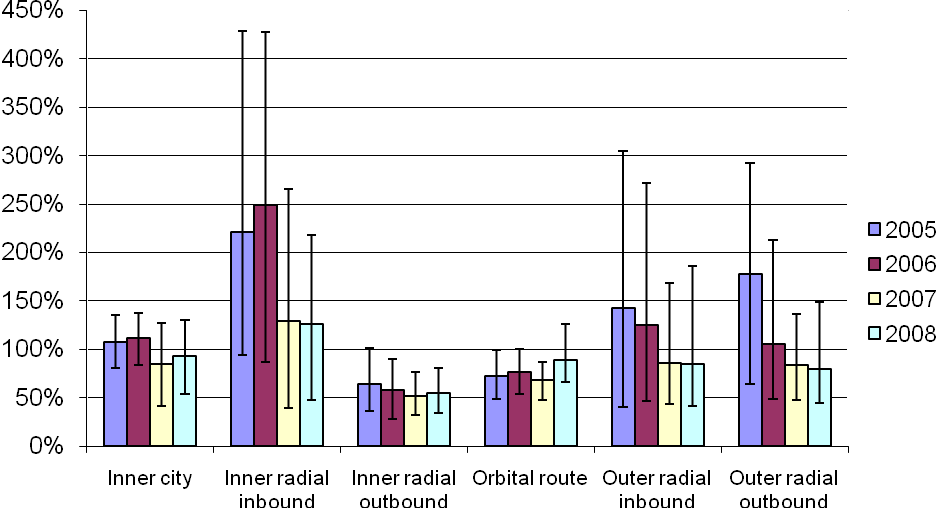
Indications that charges have no great impact on the congestion are also found for other links outside the cordon. The trend in traffic volumes has also been followed up for some particular links for which there was concern that congestion would increase. However, these links did not suffer from any significant increase in volumes during the trial (April 2005-April 2006), and the traffic increase since then has been limited.

In summary, the cordon system in Stockholm does not, therefore, seem to have generated any severe second-best problems in either the short or long term perspective.

### Journey times and congestion

Since April 2005, the primary data source for travel times has been the travel time measurement camera system, operating until November 2008. Previous analyses of these display how travel times decreased dramatically during the trial in 2006, especially on the approach roads but also in the inner city. When the permanent system was introduced again in 2007 the level of congestion decreased to approximately the same levels as during the trial (Eliasson, 2008).

In 2008, the cameras were not maintained and functioning as well as in previous years, and there are only data for a few links, making the comparison between years less reliable and representative. Still, measurements taken from all weekdays for approximately six consecutive weeks in October 2007 (after the charges had been reintroduced) and in October 2008 provide some evidence that the level of congestion has remained virtually unchanged since the congestion charges were re-introduced; see Figure 3. There is no data for 2009.



**Figure 3: Relative increase of travel times for four different types of links. 0% corresponds to free-flow travel time. The coloured bars show average travel times while the ‘‘error bars” indicate the worst decile and the best decile of the travel times distribution.**

## The exemption for alternative fuel vehicles

There are several incentives in Sweden to promote the sales of “clean vehicles”. Fuel cost is kept low due to the fact that there is no tax on renewable fuels, and clean vehicles are exempted from parking charges in some cities. In addition to these incentives, it was decided that alternative fuel vehicles were to be exempt from congestion charges in Stockholm. Two key questions emerge: Did this exemption have any effect on the sales of alternative fuel vehicles, and what effect did it have on congestion levels? This section aims at addressing these questions.

At the time of the trial, “clean cars” were defined in Sweden as alternative fuel vehicles, including ethanol, biogas (CNG), hybrid and electric cars. Since the congestion charging trial, the definition of clean cars has changed and now includes petrol and diesel cars emitting less than 120 g CO2 per km. Still, when congestion charges were introduced permanently, the old definition of clean cars was kept. The alternative fuel car exemption will now be phased out. Newly registered alternative fuel vehicles are no longer exempt and alternative fuel cars registered before 31 December 2008 are only exempt until 2012.

### Effects of the alternative fuel car exemption on sales

During the trial in the spring of 2006, 2 % of passages were alternative-fuel vehicles. In December 2008 the share of alternative fuel vehicles had increased to 14%. In 2009, this share did not decrease appreciably. The exemption from congestion charges was not the only incentive for alternative-fuel vehicles – there have been several other local and national incentives to increase the market share of clean vehicles (the new definition also includes low-CO2 emission petrol and diesel cars). In the city of Stockholm, free residential parking for clean vehicles was introduced in 1997. Measures applying to the national level have included no tax on renewable fuels, and an obligation for each petrol station to sell at least one type of alternative fuel, a special queue for clean taxis at Arlanda airport, lower value of fringe benefits for tax assessment for clean company cars and a national purchase subsidy for clean vehicles of € 1 000.

In 2008, sales of clean cars grew at a record pace in comparison to other European countries. One third of all cars sold in Stockholm and a quarter of all cars sold in Sweden were clean cars. Figure 4 shows the development of clean car sales from 2001 to September 2009 for Stockholm and Sweden (The sales after September 2009 are not yet available). The sales of alternative fuel cars have increased by 23% from 2005 to 2008 in the Stockholm County. Note that the “Low-CO2 cars” were not exempt from charges.

**Figure 4: Share of clean car sales relative to total sales of new cars, 2001-2009 (2009 sales refer to January-September). The bars show the sales in Stockholm, while the line shows the sales in Sweden as a whole (including Stockholm)**

As can be seen in the figure, the sales of clean cars were greater in Stockholm than in Sweden in 2006 and 2008. In 2007, when charges were abolished, the sales rates were approximately the same in Stockholm and Sweden, indicating that the local incentive of congestion charges exemption had a clear effect on the sales of alternative fuel cars in Stockholm.

In order to obtain a more detailed understanding of the mechanism behind the clean vehicle market, the Environment and Health Administration in Stockholm has studied the impact of different incentives on clean car sales. With statistical analyses they have quantified the importance of different factors/incentives. (City of Stockholm Environment and Health Administration, 2009). Two types of statistical analyses were carried out, producing consistent results: one time series analysis and a cross-section analysis. The time series analysis used monthly sales data and combined it with dates of introduction of different incentives and the development of fuel prices. This allows us to verify the importance of an incentive. The cross-section analysis used information about the share of clean cars per municipality and how the incentives varied across these municipalities. With this analysis, it is possible to verify whether the share of clean vehicles depends on a local incentive. The study was carried out to investigate the market in Stockholm County.

Both studies showed that the most important incentive was the exemption from congestion charges. The lower cost for alternative fuels (compared to conventional fuels) had a similar positive effect on sales. The free residential parking for clean vehicles had a lower impact on sales. The reduction of € 1 000 on the purchase price has mainly affected the sales of small city cars with low-CO2 emission (which are not exempt from the congestion charges).

The largest proportion of sold clean cars was company cars: 91 % (about 60% of all new sold cars in Sweden were company cars). This is perhaps surprising, since one would expect that drivers with privately owned cars would be more cost-sensitive. There are two likely explanations for this. First, handling the charge payments for each passage for each vehicle involves quite an extensive administrative load for a company. Buying an alternative fuel car alleviated this administrative burden. Second, the company was able to show their customers that they accepted their environmental responsibility.

### Effects of exemption of alternative fuel cars on congestion levels

The increased share of alternative fuel vehicles has only contributed to a minor increase in traffic volumes across the cordon, because this segment of drivers is not as price-sensitive as the average drivers. Most alternative fuel vehicles are taxis (2.6% out of 14%), company cars or cars in commercial traffic (8.2% out of 14%). Moreover, for company cars, the tax-deduction regulation would apply if alternative fuel vehicles had not been exempt. Only 3.2 % of cars crossing the cordon are private motorists driving an alternative fuel car.

From 2010, alternative fuel cars will no longer be exempt. Since, however, drivers of exempt cars are less price-sensitive than on average, the impact on traffic volumes will be limited. Taking away the exemption for alternative fuel vehicles, however, increased revenues.

## Political and public acceptability

Congestion charging is met with public resistance in most cities, and Stockholm was no exception. The resistance became even fiercer because of the way congestion charges were introduced. The leader of the Stockholm Social Democrats, Annika Billström, had promised before the election in 2002 that there would be no road pricing in Stockholm during the next election period. But after the general election, the Green party forced through a “full-scale, several-year trial with congestion charges in Stockholm” as a condition for supporting a Social-Democratic national government. The Social Democrats on the national level leaned on Mrs. Billström to accept a charging trial, in order not to jeopardize the formation of a Social-Democratic government. This breach of promise coloured the debate about the congestion charges long after the decision to carry out a trial, even turning many potential supporters against the charges.

Among the many surprising experiences in Stockholm, this is arguably the biggest: how the charges managed to survive an extremely heated process and gain both public and political support to the extent that the existence of the charges is now virtually a non-issue. In this section, we will discuss how this happened and what general lessons can be learnt. First, we give a brief review of how public and political opinions have evolved. The following sections discuss public and political acceptance. Finally, we discuss the consequences for transport investment planning in general.

### A brief review of opinion and politics

When the decision was made to carry out a “congestion charging trial” in Stockholm, it was met with great resistance – although not compact. In the spring of 2004 and the spring of 2005, 40% of Stockholm citizens stated that they would “probably” or “most likely” vote yes to permanent congestion charges. Support fell, however, once the start of the trial approached. Right before the start of the trial, support had fallen to 36%, with the “most likely yes” group falling the most. Once the trial started, however, support increased to 52%. The media image also changed once charges were in place, from intensely critical to, in many cases, very positive. The percentage of trial-related newspaper articles with a positive angle increased from 3 % in the autumn of 2005 to 42 % in the spring of 2006, while the share of negative newspaper articles was almost halved from 39 % to 22 % (Winslott-Hiselius et al., 2009). The trial ended on 31 July, 2006, and was followed by a referendum in September at the same time as general and local-government elections were held. Excluding blank votes, 53% of Stockholm citizens voted to keep the charges. After the election, the centre/right coalition gained power both at the national level and in the city of Stockholm. The centre/right coalition in Stockholm had opposed the congestion charges, but had promised to follow the outcome of the referendum, so they had to ask the national Government to reintroduce the charges permanently. After a few weeks of consideration, the new centre/right Government said it would do so, but as part of a broader package of transport investments in Stockholm, to be negotiated. The revenues from the congestion charges were earmarked for road investments. On the other hand, the investment package also contained major rail investments, but these were claimed to be financed by other sources of funding. After the decision to include the charges in an investment package, no political parties proposed abolishing them anymore.

The charges were reintroduced permanently in August 2007, although the negotiation over revenue use was not settled until late 2007. A poll in December 2007 showed a 66% support for the charges. A poll in August 2009 phrased the question as “Do you think the congestion charges should be decreased, increased or stay as they are?”. 56% wanted to keep them as they were, 18% wanted to increase them and 26% wanted to decrease them. Although the formulation of the question makes it hard to compare it with previous polls, the outcome can reasonably be interpreted as a 74% support for the charges.

### Factors affecting public acceptability

So what has caused this unexpected and (to our knowledge) unique public support? More precisely, what caused the opinion to change? Several authors have argued that acceptability of road pricing is likely to increase with familiarity (e.g. Jones, 2003), and this is supported by empirical experience (for Norwegian experience, see Tretvik, 2003, and Odeck and Brååthen, 2002; for London, see Schade and Baum, 2007). Several reasons for this phenomenon have been suggested, all of which may contribute to some extent.

1. Benefits may turn out to be larger than anticipated. Several authors have noted that a major reason for the resistance to congestion charges is that they simply will not work (see e.g. Jones, 2003, and Bartley, 1995). If they in fact prove to be effective in the sense that congestion decreases, then attitudes may grow more positive.
2. The downsides of charges – increased travel costs and/or changes in travel behaviour – may prove to be not as bad as expected. Once the charges are in place, many people may discover that the charges do not in fact affect them as much as they had thought. Stockholm evidence of this phenomenon is reported in Henriksson (2009).
3. Once the charges are decided, resistance may decrease due to the psychological effect known as cognitive dissonance (Festinger, 1957), a phenomenon that can be simply summarized as “accept the unavoidable”. In other words, once the charges are in place, it is less worthwhile spending energy on opposing them. Schade and Baum (2007) show that respondents in an experiment are more positive to charges if they have been led to believe that charges are certain to be implemented.
4. Familiarity with road user charging may reduce the general reluctance towards pricing a previously unpriced good. There is evidence that “people in many cases do not like prices as an allocation mechanism” (Frey, 2003; see also Jones, 2003). But once familiar with the concept that road space is in principle a scarce good that can be priced – much like parking space or telecommunication capacity – this reluctance may tend to decrease.

While the first two reasons above are related to the objective effects of the charges (decreased travel times, increased travel costs etc.), the second two are related directly to individuals’ attitudes. Attitudes, behaviour, objective effects and how effects are perceived are all interrelated, as shown in Figure 5 (from Eliasson and Jonsson, 2009):



Figure 5: Interactions between attitudes, travel behaviour and the objective effects of the charges.

The objective effects of the charges cause two types of perceived effects. First, there are direct effects on the individual, such as changed travel costs and travel times. Naturally, these effects depend on the individual’s travel behaviour. Second, there are “social” effects, system level effects that do not directly affect the individual. It is known, however, that not only direct, individual effects but also such “system” or “social” effects affect attitudes (see Jaensirisak et al. 2003; Bamberg and Rölle, 2003; Jones, 2003). Attitudes also depend on individual characteristics and preferences, such as political views, environmental concerns, or acceptance of pricing as a policy instrument. Finally, attitudes also affect the *perception* of system effects, creating a mutual dependence: a respondent with a positive attitude to charges is more inclined to believe that the charges have had beneficial effects, and vice versa. This may cause a “feedback loop” between the attitudes and the perceived system effects, where information that strengthens already held attitudes is given more weight, thereby reinforcing the attitudes (in either a positive or a negative direction). As Rienstra et al. (1999) conclude, claiming that congestion charging is ineffective can be a strategic response to justify a negative attitude towards charging.

Three recent papers have investigated explanatory factors behind the positive opinion in Stockholm (Hårsman and Quigley, 2009; Eliasson and Jonsson, 2009; Brundell-Freij and Jonsson, 2009). The papers have different perspectives, but taken together, they support all the processes and mechanisms described above.

* Hårsman and Quigley (2009) analyze referendum data and compare referendum results for each voting district with traffic effects and parliamentary election results. They show that both traffic effects and political views affect referendum results. Voting districts which benefit more in terms of travel times or lose less from increased travel costs also show stronger support for the charges. Referendum results are also strongly correlated with political views: the support for charges is strongly correlated with the support for political parties that are in favour of the charges.
* Eliasson and Jonsson (2009) analyse attitude data from December 2007, i.e. in a situation where respondents are familiar with the congestion charges and their effects. They show that the effects of the charges, both on an individual level and on a system level, affect acceptability. Moreover, attitudes to general environmental problems strongly affect acceptability – strong environmental concerns increase support for the charges. They also show that there is “feedback loop” between attitudes to the charges and perceived system effects: positive attitudes to the charges increase the belief that the charges have had beneficial effects, and vice versa.
* Brundell-Freij and Jonsson (2009) study how belief in the effectiveness of the charges changed over time, and how this affected support for them. They conclude that belief in the effectiveness of the charges strongly affects opinions about them, but that the increasing belief in effects during the trial cannot entirely explain the increase in the support. They argue that the cognitive-dissonance phenomenon most likely also contributed to the change in opinion. They also show that even those who did not believe in the effectiveness of the charges became less negative over time. This may be both because of cognitive dissonance and because they discovered that the anticipated negative effects of the charges were less than expected.

### Achieving public acceptance: Moving beyond ”winners/losers”

In the simplest textbook analysis of congestion charges with homogeneous users and aggregate supply and demand curves, all users will be worse off: either they are priced off the road to a second-best alternative, in which case they will obviously be worse off, or they stay on the road, in which case they will pay more than their value of the time gain. Theoretically, the revenue from the charges is sufficient to compensate the losers, so the standard recommendation in the acceptance literature is that congestion charges must be part of a “package”, within which it is clear how the income is going to be spent to the advantage of the general public, if it is going to have any chance of being accepted. (See for example Goodwin, 1989; Jones, 1991; Small, 1992). In the case of the Stockholm trial, however, virtually none of the income would be used for the direct benefit of motorists. While some of the income was used to improve public transport during the course of the trial, not many were able to take advantage of this. When the charges were reintroduced, most of the revenues were to be spent on a ring-road, which presumably increased acceptance among motorists (although there are unfortunately no studies of this). But it was evident that revenue use was less decisive for acceptance than expected.

Much of the economically oriented literature is concerned with the question of the “winners” and “losers” of congestion charges (see e.g. Eliasson and Mattsson, 2006), and the influence such equity effects may have on acceptability. The three papers above (especially Hårsman and Quigley (2009)) confirm that individual costs and benefits affect acceptability in the expected way. But all the papers also show that acceptance depends on many more factors than just the ”winners/losers” dimension. It is also apparent that the simplest versions of transport-economic theory neglect some crucial aspects related to ”winner/loser” analysis:

1. *The standard analysis of congestion charges underestimates the number of “winners” and the total benefit of congestion charging.* This is because the standard “textbook” analysis neglects three things: dynamics, network effects and user heterogeneity. In a *dynamic* model, where users can adjust their departure time, users will not necessarily lose from a congestion pricing reform. In the simplest case with a single bottleneck, the optimal toll will shift travellers to arrive at a rate that never exceeds the bottleneck capacity. Hence, there will be no queue, the toll and rescheduling costs will not exceed time spent in queue before the toll, and no user will be worse off (see Vickrey, 1969; Arnott et al., 1993, 1994). *Network effects* will mean that some drivers will benefit from time savings without paying the charge. If a charge reduces traffic in a congested bottleneck, allupstream traffic will benefit – not only drivers actually going through the bottleneck and hence paying the charge. *Heterogeneity* among travellers will mean that congestion charges will tend to “sort” trips such that high-valued trips will stay on the road (and enjoy time benefits), while low-valued ones will be priced off. From an acceptance perspective, the important point is that individuals can belong to different valuation “groups” on different days or different journeys.
2. *Perceived “system” effects also affect acceptability*. In other words, it is not just perceived individual costs and benefits that determine acceptability. Hence, the “branding” of the charges matters – how they are marketed, explained and perceived. A condition for this to be possible is that the system design is well aligned with the stated purpose of the charges. In Stockholm, the support for the charges was closely correlated to general environmental attitudes. Hence, the labelling of the charges as “environmental charges” and emphasizing their positive effects on air quality probably increased acceptability. While most of the social benefits of congestion charges will in general be time savings, decreasing car traffic will also generate environmental benefits, such as improved local air quality, perceived urban environment and (to some extent) reduced carbon emissions. Many people are ready to suffer inconvenience or increased costs for the environment, while a great deal fewer are prepared to suffer to achieve a more economically efficient use of scarce road capacity. If congestion charges are marketed only in the latter way, then it seems unlikely that they will gain sufficient public support.
3. *Identifying “winners/losers” rapidly becomes impossible.* Travel patterns are not static. Even when no external conditions change, travel patterns are much less repetitive and stable than many people think. Many of the affected drivers will be “occasional car drivers”, who drive on the charged road perhaps a couple of times each month. Less than a third of car drivers across the Stockholm cordon are “habitual” car drivers that pass the cordon each day. Moreover, identifying “winners” and “losers” is in fact only possible in the short term. Over a longer time period – a few years – the entire choice context (workplace and residence location, scheduling restrictions, leisure activities) will have changed. The charges will then have changed from being an “external shock” to being a factor considered when making all these choices. In that perspective, “winners/losers” will be impossible to identify. This is illustrated by the finding that when motorists in Stockholm were asked if the congestion charging had made them change their travelling habits, there were too few answering “yes” to correspond with the actual reduction in measured traffic volumes. Car drivers had apparently changed behaviour without even noticing it.
4. *Preferences and attitudes are not static.* As discussed above, the introduction of congestion charges may in itself change attitudes, through processes such as cognitive dissonance or less resistance against pricing as a policy measure. The paper by Quigley and Hårsman also shows that attitudes to charges are correlated to the standpoints of the political parties – and these may change over time. In the Stockholm case, one may presume that the fact that all political parties now support the charges has increased acceptance further.

### The concept of “fair” charges

Another problem with the “winners/losers” perspective concerns the way this translates to the question of “fairness”. Often, if a system affects high-income groups more than low-income groups, it is claimed to be a “fair” system. Hence, “fairness” considerations – which are known to affect acceptability – are interpreted as a question of identifying “winners and losers”. In Stockholm, the equity effects were generally speaking progressive: high-income groups paid more than low-income groups, men paid more than women, employed more than unemployed etc. (Details can be found in Eliasson and Mattsson, 2006; Eliasson and Levander, 2006; Franklin et al., 2009.)

But once the charges are in place, and the short-term winner/loser perspective fades, another perspective becomes more important: what price is actually “fair” to charge for a car trip? From this perspective, it is “fair” that one pays more to drive on a congested road or to cause emissions in densely populated areas – irrespective of income or place of residence, or what a hypothetical travel pattern would have been without the charges. This means that a system needs to be perceived as “fair” in this sense: it needs to be consistent with its stated objective. In Stockholm, one of the most common objections to the system nowadays is that traffic within the cordon is not charged. Although there are two good answers to this (the congestion is mainly located on the arterials along the cordon; most of the traffic inside the cordon crosses the cordon at some point on the trip), this shows how the debate has moved from “who wins/loses” to “what’s fair relative to the objectives”.

### Political acceptability

Political acceptability is different from public acceptability. Obviously, political acceptability is influenced by the level of public acceptability – but public acceptability is neither a necessary nor a sufficient condition for political acceptability. Crucial for the analysis and understanding of political acceptability are power issues: the power over the design of the charging scheme, the power over the revenues, and how the charges and their revenue stream will affect decisions and funding of transport investments in general. The fact that congestion charges are now politically accepted in Sweden is not only, or perhaps not even primarily, due to the higher public support. It is also because the charges have been integrated in the general transport investment planning process, and this has – at least partly – solved the power and negotiation issues above.

To understand the political and institutional drivers behind this development, one must start with the legal context. Swedish congestion charges are not “charges” but national “taxes” from a legal point of view. Existing infrastructure cannot be “charged”, only “taxed”, according to the constitution’s definition of a charge, and Swedish municipalities[[11]](#footnote-11) cannot levy taxes on other than their own citizens. Hence, although it was the city of Stockholm that was responsible for designing the charging system and carrying out the congestion charging trial, the responsibility for actually levying and administering the charges had to be assumed by the national government[[12]](#footnote-12). More important, this meant that it is the national government that has the formal power over both scheme design and revenues. Although the Government promised to refund the revenues to the Stockholm region, disagreements quickly emerged regarding how revenues should be calculated, how revenues should be used and which vehicles should be exempted. Further disagreements, such as whether and how charge levels should change along with inflation and economic growth, can be expected. Many politicians have stated that their main argument against introducing the congestion charge was the uncertainty about the political power over scheme design and revenues.

Adding to these uncertainties was the uncertainty about how the existence of the new revenue stream would affect the complicated negotiation between national and regional levels about national infrastructure grants. Most of the major transport investments in Sweden are paid for by the national government, whereas municipalities and regions are responsible for local streets and transit operation. As expected, there is often disagreement on where the border between different responsibilities should lie. The politicians in Stockholm, regardless of political colour, had long argued that they were not receiving their fair share of national infrastructure grants. Whether this claim was founded or not, it meant that the arrival of a new revenue stream in the form of congestion charges was not necessarily welcomed. Several politicians feared this would mean that Stockholm would have to pay an even larger share of transport investments with their own money. The government, they argued, would point to the revenues from the congestion charges and claim that Stockholm obviously needed even fewer national infrastructure grants than before.

The solution to this dilemma was the so-called “Cederschiöld agreement”, named after the chief negotiator appointed by the Government. In this agreement, the charge revenues were funding parts of a major transport investment package, where the national government also made a major funding commitment – much larger than had been the case for a long time. The charge revenues were earmarked for the road investments in the agreement, while the substantial rail investments were claimed to be paid for with money from other sources. An agreement was settled in late 2007, eventually only between centre/right parties on the national and regional levels. With this, support for the charges had been secured from regional politicians of all parties. Ironically, the Cederschiöld agreement contained several investments that the Left and Green parties – the original main proponents of congestion charges – had been opposing for many years. The result was a situation where all parties agreed to keep the congestion charges, but with different main motives, ranging from car traffic reduction (Lefts and Greens) to investment funding (Centre/Right parties), and with different opinions on how the revenues should be used.

### The impact on the Swedish transport investment planning process

The Cederschiöld agreement was a forerunner for a major change in the Swedish investment planning process. As part of the preparation for the national investment plan in 2010-2021, the Government declared that investments receiving regional co-funding would be given higher priority. There were two reasons for this: to increase the total amount of available funds, and to give regions better incentives to prioritize among their suggested investments. Regional co-funding could come from any source, but several regions jumped at the opportunity to introduce congestion charges as a means to obtain such funding. Congestion charges are in fact now being introduced in several other cities, with Gothenburg (Sweden’s second largest city) leading the way. In these cases, the main motivation for introducing charges is to finance transport investments, in contrast to Stockholm. In several cases, “congestion” charges are a misnomer, since the cities have no traffic congestion at all (with Gothenburg a possible exception). Gothenburg is a particularly illuminating example of the loose connection between public and political acceptance. In Gothenburg, a broad political consensus was formed, where congestion charges would pay for roughly half of a large investment package, with the other half coming from the Government. This is a surprising and stark contrast to the extreme controversy when Stockholm introduced charges, and even more surprising considering that acceptability levels in Gothenburg have always been very low, typically hovering around 20%. Despite this, Gothenburg politicians from all parties are now embracing congestion charges.

Giving regions the incentive and opportunity to introduce road user charges to obtain transport investments, where regional funds are leveraged by national funds, may fundamentally change the transport investment planning process. There are several advantages: regions are given an incentive to prioritize between transport investments and other responsibilities, as they are forced to “put their money where their mouth is”. When there is congestion, regions are more likely to introduce congestion charges, which is obviously a potent and efficient policy measure. On the other hand, there are several disadvantages: since regional funding is leveraged, regions will be tempted to overinvest in transport infrastructure relative to other types of (non-leveraged) spending. Charging traffic above the marginal social cost – which financing charges will probably do – will typically cause deadweight losses (although this depends on the net benefit of the investment and the deadweight loss of alternative funding sources). Whether future Governments will be able to control what they have let loose remains to be seen.

## conclusions

When congestion charges were introduced in Stockholm January 2006, the effects were substantial and immediate. Since then, however, there has been an ongoing discussion about whether the effects are likely to wear off over time, when drivers become used to paying the charge. In this paper, we have shown that the effects of the charges have instead increased slightly over time, once factors such as employment growth, inflation and changed tax regulations are controlled for. In other words, the long-term cost elasticity turns out to be somewhat higher than the short-term cost elasticity. This is in line with what is usually found when comparing long and short-term elasticities, since more adaptation mechanisms are available in the longer term.

Two other fears were that the charges would lead to increased congestion problems on other links, especially the bypasses, or that the freed-up road space within the cordon would quickly be filled up with other traffic. After four years, there is no evidence of these effects. Similarly, the improvements in travel times and travel time variability remain (although in this case, data for 2009 is scarce).

In an effort to stimulate demand for alternative-fuel vehicles, such vehicles were exempted from the charge up until the end of 2009. This policy has had a considerable effect on the sale of alternative-fuel vehicles.

Perhaps the most surprising effect of the Stockholm charges was the change in public and political acceptance, from vehemently negative to considerable support. We argue that it is necessary to consider public and political acceptance separately: while political support is certainly connected to public opinion, public support is neither a necessary nor a sufficient condition for political support.

There seem to be several reasons contributing to the public support for the congestion charges in Stockholm. The most striking effects were of course the reductions in congestion and emissions, and this has certainly increased support for the charges. But conversely, the discovery that the charges were not as bad as feared also played a role: adaptation and increased travel costs proved be less of a burden than many seems to have anticipated, especially seen over a longer period of time.

The essential factor for achieving political support in Sweden for congestion charges is the integration of the charges into the national investment planning process, thereby giving local and regional politicians substantial influence over the use of the revenues. Political support would most likely increase further if regional politicians were given more power over system design (charge levels, exemptions etc.). Moreover, the charge revenues are leveraged with additional national investment funding. The practice of leveraging regional funds with national ones can prove troublesome, since it creates incentives to over-invest in transport investments to the detriment of other public sectors. However, this is still an improvement compared to past practice, where regions seldom had to co-fund transport investments at all.

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1. Quote Gunnar Söderholm, social-democratic head of the Congestion Charging Office during the trial, when (after the trial) describing the local Social Democrats’ feelings when the national Social Democratic government more or less forced the congestion charges onto the local Stockholm party district. [↑](#footnote-ref-1)
2. Throughout the paper we have converted SEK to Euro using a conversion rate of 10 SEK/€. [↑](#footnote-ref-2)
3. For months when charging was applied, the numbers in Figure 1 are those that were registered by the charging system, and therefore very precise. For other periods, numbers are to some extent estimated based on calculations from other traffic counts. Comparability between years for corresponding months is somewhat compromised by calendar effects: a number of national and school holidays alternate between months. [↑](#footnote-ref-3)
4. In 2008-2009 the congestion charging system was not operating in July, and hence there are no measurements. [↑](#footnote-ref-4)
5. The figures for June and July 2007 are affected by major roadworks. [↑](#footnote-ref-5)
6. The exact size of the residual effect is uncertain, since data from this period are less reliable due to road works and technical problems with the measurement equipment. [↑](#footnote-ref-6)
7. The trip must be longer than 5 km and the commuter must save at least one hour compared to public transit one way; or, the commuter must need the car for work purposes. [↑](#footnote-ref-7)
8. Alternative fuel vehicles bought in 2010 or after are not exempt. Alternative fuel vehicles registered before 1 January 2009 are only exempt from the charges until 1 August 2012. [↑](#footnote-ref-8)
9. For trips crossing the cordon twice, trip length is divided by two in this calculation. [↑](#footnote-ref-9)
10. Detailed calculations and data sources are available on request from the authors. [↑](#footnote-ref-10)
11. A ”municipality” (”kommun” in Swedish) is the smallest geographical administrative unit in Sweden, roughly corresponding to a city. Most of the spatial planning responsibility, including infrastructure planning, lies at the municipal level. [↑](#footnote-ref-11)
12. This task was given to the National Road Administration, and later moved to the National Transport Agency. [↑](#footnote-ref-12)