



Facts and results from the Stockholm Trials

Final version – December 2006

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Brief summary of the conclusions drawn by the expert group

Most of the goals of the Stockholm Trial have been achieved. This was clear in August when the expert group presented a collective picture of the effects of the trial. Most road-users have their own perception of how the trial works; this perception is based on how the trial affects them as individuals. The evaluation provides a supplementary collective picture of the overall effects of the trial in a number of areas.

The three primary goals of the trial were reduced traffic, a better environment and perceived improvements to the city environment. The goal of traffic reduction has been achieved, and thereby also the environmental goal. The degree of achievement of the city environment goal is more difficult to interpret.

The trial cut traffic flows – even more than expected – and the reduction was surprisingly stable if normal seasonal variations are taken into account. In addition, the effects were noticeable further away from the congestion-charge zone than we first anticipated. This also means that several of the feared “side effects” did not materialise. Access increased, which had a major positive impact on travel times and also meant that you could be more certain that your journey would take a specific amount of time.

The effects naturally varied for different times and routes. Traffic decreased on most major roads, but increased on others. In general these increases are however significantly smaller and fewer in number than the large-scale decreases. Traffic fell more in the afternoon than in the morning, and more across the actual charge zone cordon than within the inner city or further away, outside the cordon. Traffic increased somewhat on the Essingeleden and Södra Länken bypasses.

The Stockholm Trial reduced emissions of both carbon dioxide and particles. This reduction is substantial to have been achieved through one single measure. Seen across the county as a whole however, it can only be regarded as one of several measures required to achieve national climate objectives, for example. As the reduction in traffic took place in densely populated areas, the reduction – mainly of particles – brought a major health benefit to the county as a whole. The health benefit is about three times higher than the benefit that would have been gained had the reduction occurred through an increase in fuel prices. As expected and in general terms, the Stockholm Trial only had a marginal impact on noise levels.

The city environment is a complex and diffuse concept, without a given definition. It is also difficult to measure. It is therefore risky to comment on the goal on a more general level. It is clear however that people perceive the city environment improved in those respects for which changes can be measured. The results show that there is perceived improvement of the factors that are linked to the reduction in traffic: traffic speed, air quality and access for motor vehicles.

The vast majority of journeys to and from work or school that crossed the

charge cordon and that were no longer made by car due to the Stockholm Trial were made using public transport. A small proportion of motorists instead changed their routes to avoid the congestion tax, for example by choosing to travel via the Essingeleden bypass. There was no increase in telecommuting or use of car pools. A much smaller proportion of journeys that were made for other reasons and that crossed the charge cordon seemed to have switched to public transport during the trial. Instead, people changed their destinations or re-organised their travel in different ways, for example by making fewer journeys.

A large proportion of motorists in the county paid congestion tax at least from time to time, but very few did so regularly to accumulate extremely high costs. Nevertheless, this small group accounted for a relatively large proportion of the congestion tax revenue.

The groups who, on average, paid most congestion tax per person consisted of men, high-income earners, married/cohabiting couples with children, and residents of the inner city and Lidingö.

The expanded public transport during the trial did not reduce motor traffic to a demonstrable extent. Effective public transport is however necessary to cope with the larger number of public transport users.

The regional economy was not affected to a greater extent, and it is not likely that it would have been in the long-term. In macro-economic terms, a congestion tax system becomes profitable after four years.

Both the general public and business owners have gradually become more positive to the tax and the trial from their own experiences and when the benefits started to emerge.

Preface

On 2 June 2003 Stockholm City Council decided to suggest a trial period for environmental charges/congestion tax – the Stockholm Trial. The Swedish Parliament, the Riksdag, decided to pass the law on congestion tax (Swedish Code of Statutes SFS 2004:629) on 16 June 2004. The law enabled congestion tax to be charged in Stockholm until 31 July 2006 inclusive. On 28 April 2005, the government decided that the trial period for environmental charges/ congestion tax in Stockholm would start on 3 January 2006. The main players in the Stockholm Trial were the City of Stockholm, the Swedish Road Administration and SL – Stockholm Transport. The trial was funded by the government.

The Stockholm Trial consisted of three parts: expanded public transport, environmental charges/congestion tax and additional park-and-ride sites in the city and in the rest of the county.

The goals of the trial:

- A 10-15 per cent reduction in the number of vehicles that cross the inner-city segment during morning and afternoon rush hours.
- Improved access on the busiest roads in Stockholm traffic.
- Reduced emissions of carbon dioxide, nitrogen oxides and particles in inner city air.
- Better street-level environment perceived by people in the inner city.

The Congestion Charge Secretariat is the project office of the City of Stockholm. Its task, as commissioned by the government, is to plan, coordinate, inform of and evaluate the trial. The Congestion Charge Secretariat has drawn up a comprehensive evaluation programme to assess the extent of goal achievement and the effects of the Stockholm Trial. This programme has been drawn up together with the Swedish Road Administration, the County Office of Regional Planning and Urban Transportation, Stockholm Transport, various research institutes (including the Faculty of Engineering at Lund University and the Royal Institute of Technology), independent consulting companies (including Transek and Trivector) as well as some city administrations (the City of Stockholm Traffic Administration, the Stockholm Office of Research and Statistics and the Environment and Health Administration). The measuring work, analyses and reports have been conducted and produced by government agencies and administrations as well as consulting companies that specialise in the different sub-areas of the evaluation programme. All evaluation reports are available on the trial's website: www.stockholmsforsoket.se.

This report contains conclusions on the effects of the Stockholm Trial as compiled by an expert group as well as summaries from the surveys conducted. The first version of this report was published on 21 June; it has now been updated with additional results and conclusions.

The initial project leader of the evaluation programme was Joanna Dickinson, MSc in Engineering. She was succeeded by Muriel Beser Hugosson, PhD in Technology (Feb. 2005) and Ann Sjöberg, Licentiate of Technology. In addition to the project leaders, Camilla Byström (PhD in Technology), Annika Lindgren, Oscar Alarik, Litti le Clercq, David Drazdil, Malin Säker and Ann

Ponton Klevstedt have worked on the evaluations.

Stockholm, 15 August 2006

Gunnar Söderholm
Head of the Congestion Charge Secretariat

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The conclusions of the expert group

Introduction

A summarising analysis of the evaluation of the Stockholm Trial has been published in two stages: in June and in August 2006. The analysis was supplemented in August with the documents presented during the summer. This supplementary information describes adaptation to the congestion tax (for example, what has happened to the car/lorry trips that used to cross the charge cordon, and what types of trips and road users have adapted most) as well as an analysis of how the different effects of the trial are distributed among different groups. In this complete evaluation the expert group has also summarised the most important points from the different evaluation reports.

Presentation of the expert group

The expert group consists of eight traffic experts with different special fields. The group members read all the underlying reports and, during four intensive whole-day seminars, they reached the conclusions presented in this summarising evaluation of the Stockholm Trial. The majority of the group members also took part in the preparations for the evaluation in various ways, and worked on monitoring the effects during the trial.

The chair of the group was Jonas Eliasson and the secretary was Lena Smidfelt Rosqvist. Other group members were: Staffan Algers, Karin Brundell-Freij, Cecilia Henriksson, Lars Hultkrantz, Christer Ljungberg and Lena Nerhagen. (See Appendix 1 for a detailed description.)

Expected effects of congestion taxes in Stockholm

There were many expectations concerning the Stockholm Trial. There was also a great deal of uncertainty about how the effects would be influenced by the fact that the trial was for a limited period. There were numerous questions as to whether such a limited trial period (seven months) would lead to effects that were as substantial as shown in the traffic models. Road users might choose to “hibernate” without adapting their behaviour during the trial period. We now have answers to many of these questions, because we largely know what effects the trial actually produced.

Prior to the trial it was a well known fact that motorists are sensitive to financial incentives. It was therefore a well founded expectation that car tolls in Stockholm would reduce traffic volumes. Primarily, the reduction was expected to occur near the congestion-charge zone cordon. The size of the reduction was expected to decrease relatively rapidly the greater the distance from the cordon. But the predictions made of the size of the changes were uncertain for many reasons. The conditions of the Stockholm Trial differ in several ways from those in other locations where road tolls are used.

The expected effects on access were more uncertain than the expected effects on traffic volume. There was reason to believe that limited volume reductions might promptly lead to less congestion, but the uncertainty surrounding this was considerable, because the links between traffic volumes and journey times/congestion are very complicated.

As regards traffic across the charge cordon, the Stockholm Trial was expected to lead to more people opting to travel by public transport and (based on experiences from London) to some extent by bicycle instead of travelling by car. The expected greater use of public transport was not just due to the congestion tax but also the fact that public transport – which is part of the Stockholm Trial – was expanded.

As a direct result of reduced traffic, better road safety was also expected for motorists, especially in the form of fewer whiplash injuries. The trial period was however far too short for such changes to be measured.

The Stockholm Trial also has a clear environmental profile. This is natural, because motor traffic contributes to many of our most urgent environmental problems – not least in major cities. Although the charges were first proposed mainly to reduce congestion, a decrease in motor traffic affects the environment and people's health – especially when the decrease occurs in densely populated areas. The uncertainty concerning the effects that were expected in the form of lower emissions was linked to the uncertainty as to how large the traffic reductions would be.

The type and extent of the health benefits that can be obtained as a result of changed emission levels are not however self-evident. The links between motor traffic emissions and levels of air pollution that affect health in the city are very complicated. Only minor changes in noise levels were expected due to the trial.

There was extensive uncertainty surrounding how perceptions of the city environment would alter as a result of the trial – not least, because a city environment is a complex concept that lacks a clear definition.

The exemptions from the charges, for clean vehicles for example, were expected to lead to an increased number of such vehicles in Stockholm traffic. We expected to see a larger proportion of company cars due to lower price sensitivity for this group.

Finally we were all curious to see whether the effects of the Stockholm Trial would also be noticeable without measurements, in other words, whether residents of and visitors to Stockholm would spontaneously notice the effects.

The basis for our summarising conclusions

A large number of measurements and studies are included in the evaluation of the Stockholm Trial. These date from three periods: 1) prior to the trial with the investment in public transport in August 2005, 2) autumn

2005 and 3) after the launch of congestion charges in January 2006. The separate surveys were often decided in consultation with the Swedish Road Administration, the Office of Regional Planning and Urban Transportation (RTK), Stockholm Transport, various research institutes, some of the city's administrations and experts from other bodies, organisations and companies. The different surveys were largely conducted by consulting companies that are specialised in each field, but also by administrations in the City of Stockholm, the Swedish National Road and Transport Research Institute (VTI) and the Royal Institute of Technology (KTH).

The evaluation spans a wide range of fields. The studies do not only cover travel patterns and effects on motor traffic and public transport, but also environmental consequences, effects on trade and industry, pedestrian and cycle traffic, changes to the city environment as well as macro-economic impact and effects on the regional economy. Many of the effects of the trial are very dependent on factors in the surrounding world, such as the economic trend in the region and country. That is why studies of trade and commerce and the economic situation are included in the evaluation. Between the measurement periods before and during the trial, events in the surrounding world had an impact on the effects measured in the studies. The factors that were most significant were the increase in fuel prices and the opening of the Södra Länken bypass. A flat-rate fare has also been introduced in public transport, but this took place after measurements were made that form the basis for the information used in the evaluation. These and other external factors that may influence the effects have been taken into account in the conclusions that we in the expert group have reached and presented here.

It is difficult to perform a comprehensive follow-up and evaluation of the Stockholm Trial due to the large scope of the trial. The task has not been made easier by the short time that we had to conduct the follow-ups. A more fundamental problem is that some of the surveys *before* the trial were conducted in the autumn of 2004. The idea was that comparisons could be made with the situation one year later, because the trial was planned to start in autumn 2005. As the trial was not launched until January 2006, the comparison should have been made with data for the spring period, but by that time it was too late to collect such data. We have partly been able to tackle this problem satisfactorily, particularly in terms of traffic counts, where seasonal variations in the inner city are not large and/or we have been able to assess the situation with other data. In other cases the problem is difficult, for example regarding the travel-pattern survey for the entire county, in which seasonal variations are more considerable and less well known. Furthermore, several other significant changes took place over the 18 months between the measurement periods, such as the increases in fuel prices.

There are other factors that affect the work method and are difficult to tackle; we have already mentioned the impact of external factors on the effects of the trial. Changes also occurred during the trial period as a result of decisions made in the city and region, such as the switch to flat-rate fares in public transport. Traffic and the trial's effects also varied

during the six months of the trial, but most studies only present a snapshot of the situation at one point in time. A lot of the information used as a basis in the evaluation is derived from surveys conducted in April, i.e. after half of the trial period. Several of the studies were carried out as panel studies, in which the same individuals were asked about their behaviour before and during the trial. Panel studies have many advantages, but care must be taken in drawing conclusions, because a shift in age takes place between the measurements before and during the trial, for example.

In our assessment of the results of the studies and in our conclusions we have taken account of the reliability of the different surveys, the expected reliability of the measured results and which measuring methods were used. We have also taken account of the significance and potential of different effects. We have not therefore based our assessments solely on the results described in each individual report, but also on assessments of the significance and general applicability of the effects.

Conclusions

The expanded public transport during the trial did not reduce motor traffic to a measurable extent. Relatively well functioning public transport has however been a prerequisite for the effects produced by the congestion tax. Good and comprehensive public transport makes it easier for people to switch from their cars to public transport alternatives. But on its own, expanded public transport has little effect on travel by car. This conclusion clearly reflects well known knowledge that it is only when car travel become “more expensive” in the form of higher costs or longer travel times (traffic jams) that public transport can increase its market share to a considerable extent. This is precisely what has been happening in Stockholm over a long period of time. The city has a large proportion of public transport use. Improved public transport is not enough to reduce congestion on the roads.

If the congestion tax is implemented permanently, several experiences from the trial can be used to improve the function of the system in different ways. These experiences make it easier to formulate traffic and environmental goals for such a system. This may be very important in order to obtain the general public’s acceptance of a congestion charge as a way of improving access and the city environment.

The Stockholm Trial confirms that a simple zone toll produces tangible effects in a large area – an issue that has long been discussed.

Clear goals for the congestion charges should be drawn up. Charge levels and times can be fine-tuned, based on goals set for access and/or environmental objectives. It might be appropriate to start at 7.00 a.m. rather than 6.30 a.m.

There is reason to consider whether the levels of congestion charges should be varied bearing in mind the seasonal variations of traffic. At the

end of June and during July, traffic volumes were considerably lower than the traffic system's capacity level, which speaks in favour of lower or no charges during this period.

There is no definitive answer to the question of whether it is beneficial to traffic to exempt the Essingeleden bypass from congestion charges. Even though access on Essingeleden did not noticeably worsen during the trial period, the increase in traffic on this bypass does entail greater vulnerability to disruptions in the traffic system as a whole.

Administration and payment systems can and should be improved.

The introduction of congestion charges in cities produces major, rapid and cost-effective effects compared to other measures. In contrast to several other possible congestion reduction measures such as infrastructure expansion, congestion charging also has more positive effects on the environment and road safety.

In Stockholm, the inner city/approach roads cannot be extended. Ring roads and similar measures can only partly relieve the pressure on the existing road network (it is estimated that proposed ring roads would reduce traffic over inner city bridges by 11-14 per cent). As observed earlier, investments in expansion of public transport have little or no impact on traffic congestion.

The major winners in the Stockholm Trial were professional and service road-users, who made substantial travel time savings that were worth more than the congestion tax they paid. The net effect for private individuals depends entirely on how the congestion tax revenue is used.

Big cities will always have congestion. Congestion charges cannot and should not *eliminate* the congestion; it should simply reduce it to an acceptable level. Investments in infrastructure cannot eliminate congestion either. This is partly due to "latent demand", in that new routes generate new traffic. Increased road capacity is not always "meaningless" however, because new road users benefit from it. The conclusion is that traffic congestion is a big-city phenomenon that cannot be removed through investments in roads or public transport.

Results

Motor traffic decreased more than expected

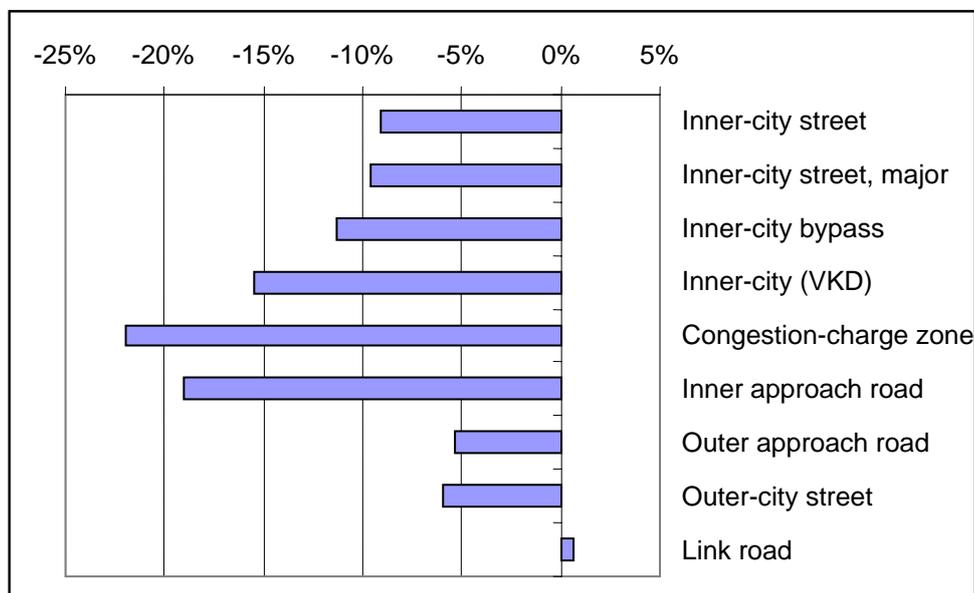
The traffic goals for the congestion taxes were that the number of vehicles crossing the inner-city segment during the morning and afternoon rush hours would decrease by 10-15 per cent, and that access would improve on Stockholm's busiest roads. The charge system was designed to meet these goals, but as already mentioned, there was a great deal of uncertainty as to what the effects would be. Many different kinds of measuring work were performed and the data was analysed to produce facts about how the traffic has changed.

The major aspects of the traffic reductions are very clear. The trial cut traffic flows – even more than expected – and the reduction was surprisingly stable if we take account of normal seasonal variations during the spring. In addition, the effects were noticeable further away than we first anticipated. Traffic volumes also decreased a long way from the charge zone. This means that several of the feared “side effects” – such as negative impact on suburban link roads – did not materialise. The reduction in traffic volumes was measured using traffic counts, but was also illustrated in other special studies.

Just as you might expect, traffic decreased most across the charge cordon. This includes all the approach roads to the inner city. The reduction for the entire congestion tax periods over 24 hours was about 22 per cent. This corresponds to nearly 100,000 passages over the charge cordon.

The decrease in traffic across the cordon was largest during the morning and afternoon rush hours. The largest reduction occurred in the afternoon, which was probably due to the fact that afternoon journeys are not as fixed in terms of times and destinations as morning commuter journeys. Traffic also fell in the evenings after the congestion tax period.

The decrease in traffic on the south-east approach road was larger than the average reduction for the entire zone. The reduction from Lidingö was however below the average. This smaller reduction from Lidingö was expected, because road users to and from Lidingö who were not travelling to inner city destinations were exempt from the congestion tax.



The figure above shows *average* traffic reductions for different types of roads and streets. Each category includes roads where traffic has decreased more and some roads on which traffic has decreased less (or in a few cases, has increased). The flow of traffic on major inner-city roads fell during the congestion tax period, but not as much as across the congestion-charge zone cordon. In terms of the number of vehicle kilometres driven, traffic in the inner city fell by more than 15 per cent. It is natural that this reduction is smaller, because the traffic flow in the inner city also

includes motor traffic from residents, etc who do not leave the charge zone; instead they use their vehicles for journeys inside the city. Furthermore, other studies besides the traffic counts indicate that the motorists who do not need to cross the charge cordon benefited from the drop in congestion and actually used their vehicles more. This might also partly explain why traffic fell less in the inner city than across the charge zone.

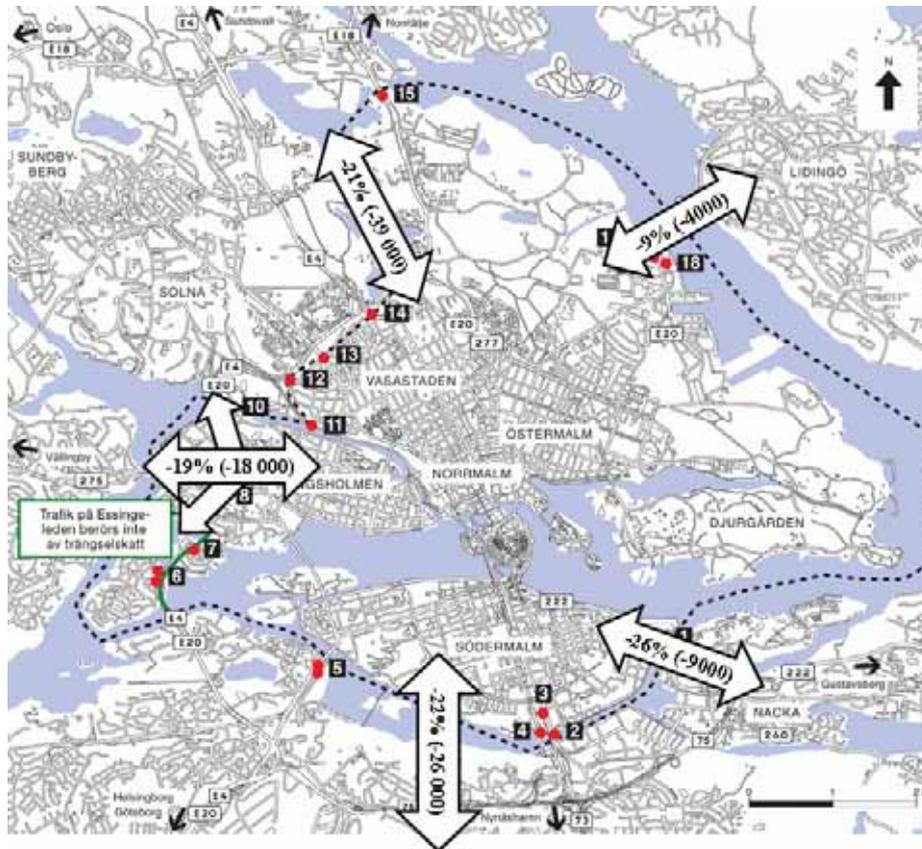


Figure 1 Percentage change in traffic flows in and out of the congestion-charge zone during the charge period (06.30–18.30) for different points of the compass. (The figures in parentheses indicate the change in the number of vehicle passages.)

/Translation. Figure 1/

Textbox: Traffic on the Essingeleden bypass is not subject to congestion tax

Fears of a collapse on the Essingeleden bypass and other ring roads did not materialise. Traffic on the Essingeleden bypass increased by 4-5 per cent compared with 2005 – quite a small increase if compared to the normal variations from week to week. As the bypass is already so busy however, even small increases in traffic tend to heighten sensitivity to disruptions. The changes on other ring roads were minor – a few had somewhat increased traffic (such as Frösundaleden and Älvsjövägen) while traffic on others decreased somewhat (including Bergshamraleden, Huvudstaleden and Magelungsvägen).

Traffic on the Södra Länken bypass has steadily increased since the bypass opened in October 2004. The degree of the increase in 2006 that is due to congestion charging cannot be determined. People usually take a long time to become accustomed to using new investments in infrastructure. In addition, the major influx of new inhabitants to the Hammarby Sjöstad district has almost certainly led to increased traffic. These effects, as well as the Lodbrok accident, had an impact on traffic volumes on the bypass and the reliability of the traffic counts. We have taken this into account in our evaluation.

The only approach road that deviates from the pattern of shorter travel times is Värmdövägen (from Nacka Centrum down to the approach road to the Södra Länken bypass). The increase in traffic on the Södra Länken also produced longer queues westwards on the road Värmdövägen in the mornings. However, travel times became much shorter than in the past after this point, in other words the stretch Värmdövägen-Statdsgården west towards the city. A similar phenomenon was noted on the road Nynäsvägen.

According to the manual counts of traffic on approach roads, the number of passages by commercial traffic crossing the charge cordon fell. It is however uncertain how these road users changed their travel patterns.

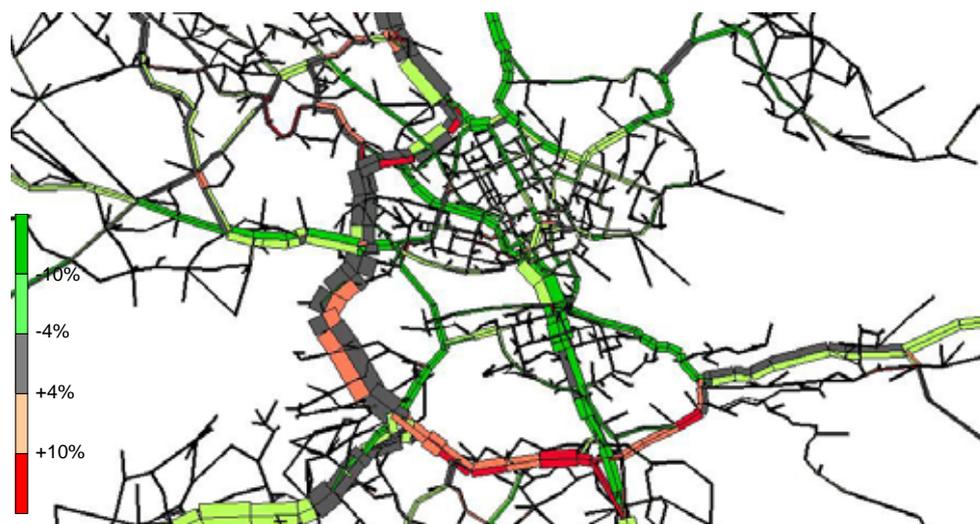


Figure 2. Change in traffic volumes (weekday day), April 2005 compared to April 2006.

Congestion rose at the end of April in parallel with the annual spring increase in traffic. It was then discussed whether this was due to fact that the effect of congestion charging had diminished over time. The greater congestion was however due to a normal seasonal increase in traffic. The reduction effect in per cent was the same as those seen in month by month comparisons for previous years. Another factor that contributed to the greater congestion – besides the increase in traffic – could be that the number of cyclists and pedestrians increased as the spring weather improved. In the locations where these road users share the roads with motorists, such as in the inner city, they take up a large amount of capacity in the traffic system. An interesting observation is that because the reduction

in per cent seemed to remain at a constant level throughout the first six months, the additional car and lorry trips that were made during the spring were affected by the congestion tax to the same extent as the trips made at the start of the trial during the winter.

Access improved

Access improved and travel times fell as a result of the reduction in motor traffic. This had a major positive impact on the reliability of travel times, in that you could be more certain that your journey would take an expected amount of time. Travel times for motor traffic fell considerably in and around the inner city. Particularly large reductions were noted on approach roads, where queue times decreased by a third in the morning rush hour and were halved in the afternoon rush hour. This was a substantial improvement for commuters travelling by car to and from the inner city, because travel times were shortened and became more predictable. In severe congestion, the differences in travel times for the same route in different traffic conditions – which can vary from practically one day to the next – are extreme.

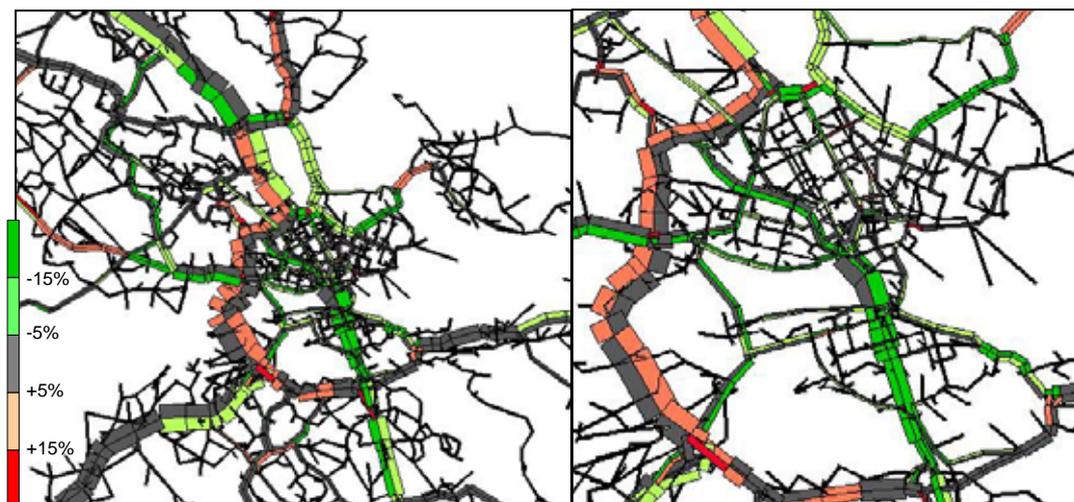


Figure 3. Change in travel times (morning rush hour), April 2005 compared to April 2006. Inner city enlarged in right-hand picture.

The severe congestion on the Essingeleden bypass causes major variations in travel times from one week to the next, even though the traffic volume is virtually unchanged. The traffic increases that we can see on the Essingeleden seem to have led to somewhat longer travel times. No systematic travel time increase between 2005 and 2006 can be established from the measuring work conducted. In some directions and at certain times, travel times increased; at other times and in other directions they decreased.

The greater traffic on the Södra Länken bypass increased travel times compared to the previous year. With the information we have obtained, it is impossible to deduce how much of the increase is due to congestion charging and how much is due to an increase in traffic that would have occurred regardless of congestion charging. Congestion charging has cer-

tainly caused part of the increase, but it is equally certain that it is by no means responsible for the entire increase.

It is clear that the reduction in traffic volume and better access have improved the work environment of professional drivers. All studies of professional drivers – bus and taxi drivers, couriers and contractors – before and during the trial, point to this to various extents.

Traffic reductions lead to less environmental impact and better health

Emissions from motor traffic account for a large proportion of the total pollution in a city. Exhaust emissions are diluted in the air with other emissions and thereby affect the city's air quality. Different pollutants or emitted substances have different effects. Sometimes the levels – the diluted amount of emissions in the air – in the environments that people occupy are of greatest significance, and sometimes the total amount of emissions has the greatest significance. In the case of carbon dioxide emissions, which have an impact on the greenhouse effect, the total amount of emissions is the most significant. Air quality in the form of levels of pollutants causes increased mortality from cardiovascular disease. Particles are what mainly affect people's health in the city. There is an incidence of lung diseases and increased health problems among sensitive groups (people with asthma and other bronchial conditions or cardiovascular diseases).

The amount of emissions caused by traffic depends on total VKD and emission factors, in other words the emissions of different substances from each vehicle per kilometre driven. VKD multiplied by the emission factor gives us the total amount of emissions (expressed in tonnes/year) of different substances. Emission factors are affected by the distribution of different types of vehicle and by how the vehicles are driven. For example, a driving pattern with large variations in speed produces more emissions than driving at an even speed. These links are complicated and it is therefore difficult, using input data, to make exact calculations of how much the Stockholm Trial decreased emissions. The emissions calculations made are based on different emissions models and differ depending on which factors have been taken into account in the calculations. However, they arrive at similar conclusions. The assumptions made in the calculations probably indicate that the effects have not been overestimated. Above all the calculations show that the reduced traffic volumes lead to lower emissions, but also that the change in distribution of vehicles is what determines how much the emissions of particles and nitrogen oxides decrease.

The Stockholm Trial reduced emissions of both carbon dioxide and particles. The drop in carbon dioxide is approximately in proportion with the reduction in VKD, which means that the contribution from traffic in the county has been reduced by 2-3 per cent, and in the inner city by about 14 per cent. These are major reductions to have been achieved through one single measure, although when regarded as a reduction for the county it

can only be seen as one of several measures required to achieve national climate objectives. Carbon dioxide emissions are the most difficult traffic emissions to reduce.

Total particle emissions have fallen by about the same amount as traffic volumes, but in the case of these substances, the place *where* these emissions decrease is of primary importance, because they contribute to concentrations at local level. The Stockholm Trial reduced the contribution from traffic by about one twentieth for the whole county and a tenth for the inner city. According to the County Administrative Board of Stockholm, reduced use of studded winter tyres is an important step towards achieving the environmental quality values for particles. On the street Hornsgatan, a ten per cent drop in the use of studded tyres would reduce levels of particles by the amount that the City of Stockholm Environment and Health Administration calculated could have been reduced through congestion charging. However, besides lower levels of particles (measured in PM10) at street level, congestion charging reduced the levels of smaller exhaust particles – a reduction that is also beneficial to health. This benefit is not achieved through reduced use of studded tyres.

There are also environmental quality values for nitrogen dioxide, NO₂. The concentrations of NO₂ at street level are not only determined by traffic emissions, but also by other factors, such as the occurrence of other substances. Emissions of nitrogen oxides (NO_x – not only NO₂) from traffic have fallen steadily during recent years because of more stringent emissions requirements on vehicles. The effect of this decrease on the concentration of NO₂ at street level in Stockholm's inner city is however much less. This is due to the complexity of factors such as chemical reactions. It was therefore not expected that congestion charging would make a major contribution to achievement of environmental quality values for NO₂.

Exposure to particles affects the health and mortality of the population. Calculations based on effects linked to premature death as a result of exposure to air pollutants show that the reduction in traffic due to the Stockholm Trial saves about five life years. This is also the expected reduction used in the cost-benefit analysis for the Stockholm Trial. New research findings – presented in one of the evaluation reports – indicate a much higher cause-effect relationship. Calculations, according to these research findings, demonstrate that up to 25-30 premature deaths can be prevented per year. This corresponds to about 300 life years.

Bearing in mind the clear risk that the impact on health may be larger than traditionally estimated, we should not disregard the importance of reduced exposure. To derive considerable benefit from a measure designed to achieve lower emissions, the reductions should mainly be made in the most densely populated areas, where many people are exposed to a negative impact on health. Congestion charging therefore has a greater effect on health per equal amount of emissions than a tax increase on fuel, for example. This is because the reduction of emissions can be controlled by deciding where to debit the congestion tax, i.e. where people are very

exposed to pollution. The reduction in emissions as a result of congestion charging in the inner city has a health benefit for the whole county that is about three times higher than the benefit that would have been gained had the reduction in emissions been achieved through an increase in fuel prices evenly distributed throughout the county.

As expected, the Stockholm Trial in general only had a marginal impact on noise levels, because major changes in traffic flows are required for people to perceive an increase or decrease in noise. The limit for people's ability to discern a difference in noise level is 3 dBA, which in traffic contexts corresponds to an approximate doubling or halving of the traffic volume.

Calculations of the noise level changes caused by the Stockholm Trial point to changes of about 1 dBA and at most 2 dBA for average levels over 24 hours. There are therefore very few places where the changes in noise levels can be discerned. However, even small changes of 1 dBA in noise levels lead to a reduction in the proportion of people who feel disturbed by traffic noise. Perceptions of noise can also be improved if people perceive less congestion and motor traffic. The city environment study contains results that indicate a perceived reduction in noise, despite the fact that it is in principle not possible to actually discern these small reductions.

Noise remains a major problem in Stockholm like in many other places in Europe, and it is now the subject of special EU directives. One goal is to create quiet zones, which places major demands on traffic reductions. It is difficult to imagine that such reductions could be feasible without powerful policy instruments to limit motor traffic.

Public transport was an important part of the Stockholm Trial

Access for bus service to, from and within the inner city has improved. Since the inner city timetables were not adapted accordingly during the course of the trial, improved access did not make travel time much shorter. Punctuality probably improved, and for bus services through the approaches, travel time was reduced considerably.

Based on the data available so far, it is not possible to show that the investments in public transport (park-and-ride facilities, expanded bus and rail services) had any visible effect on the total number of trips taken on public transport during autumn 2005, before the charges began to apply. This does not mean that there was no such effect, only that if there was, it was too small to be detectable in SL's passenger statistics or in the travel pattern study carried out in autumn 2005. It is, to be sure, unlikely that the public transport investments didn't have *any* effect on the total number of trips made using public transport, but there are not as yet enough detailed analyses or statistics to make it possible to identify such an increase. SL's on-board studies on the new bus lines indicate that they attracted motorists to public transport, but the number of added trips by public transport is nevertheless too small to be visible when viewing total public transport travel. In all, travel on SL was about 2 percent higher in autumn 2005

compared to autumn 2004, but that increase is believed to be explained by a rise in petrol price.

According to SL's measurements, travel by public transport was about 6 percent higher in spring 2006 than in spring 2005. The congestion tax seems to have caused an increase in travel by public transport by approximately 4.5 percent, while higher petrol prices and other global events probably account for the rest of the increase (about 1.5 percent). The travel pattern study shows an almost equally large increase.

Crowding in public transport (measured as percentage of standing passengers) has increased somewhat on the underground while declining on commuter trains. On the average crowding seems to have been unchanged. The expansion in public transport is presumed to be part of the explanation for this.

Another question is whether the congestion tax would have reduced car travel as much if there had been no investments made in public transport. It is true, as shown above, that the expansions in public transport did not yield a demonstrable increase in the number of trips by public transport,¹ but it is entirely possible that they strengthened the effect of the congestion tax by making the step from car to public transport shorter. If this is the case, then some of the effect of the congestion tax can just as well be accounted for as an effect of the investments in public transport.

Our belief is nonetheless that even if such an effect can be shown, it must be small. This perception is based on the fact that on-board studies on the new bus lines show that the number of new passengers between autumn 2005 and spring 2006 who previously travelled by car is exceedingly small compared to the decline in the number of passages through the congestion tax zone. Of the 22 percent decrease in car travel across the charge zone, only 0.1 percent at the most could have been caused by the expanded bus services.

The commuter train problems during the winter seem to have caused a reduction in commuter train travel. It is not clear what these passengers did instead. Some undoubtedly used other public transport connections or refrained from travelling, while others presumably chose to take their car instead. The commuter train problems have thus probably dampened some of the traffic reduction yielded by the congestion tax.

Road safety better because of reduced traffic

Road safety effects on the whole are difficult to evaluate and the short period of the Stockholm Trial makes it hard, if not to say impossible, to draw any conclusions based on the follow-up account of actual reported accidents during the trial period. The evaluations of the trial's road safety

¹ Note that we are merely speaking of a *hitherto demonstrable* effect. It is quite possible that more detailed statistics and more detailed analyses will show such an established effect in the end.

effects are therefore based on estimates and relations between road safety and changes in VKT, traffic flows and speed levels.

Research shows that road safety is primarily affected by changes in VKT and speed levels. Since traffic has declined as a result of the Stockholm Trial, this means a decline as well in the number of estimated personal injury accidents within the area of the congestion tax. The magnitude of the decline is of course uncertain, but based on the model estimates, personal injury accidents are expected to have declined by 9-18 percent. The reduced congestion however has led to higher speeds, which brings with it an expected increase of the number of personal injury accidents. This effect is not as large however as the effect of traffic reductions.

The combined effect of the Stockholm Trial on road safety is assessed to turn out undeniably positive, since the positive effects of reduced traffic are expected to be greater than the negative effects of increased speeds. A large percentage of the traffic accidents within the charge zone occur during the hours when the charge is imposed. A cautious estimate is that the Stockholm Trial has entailed a decline in the number of personal injury accidents of 5-10 percent within the congestion tax area. Converted into annual values this would be the equivalent of a decrease of between 40 and 70 personal injury accidents per year. This figure can be set in relation to an average 2,155 people who are injured in traffic in Stockholm County every year and 23 who die. A majority of those who are injured, in the county as well as in the inner city, are motorists. In the inner city over one-third of those who are injured are cyclists and pedestrians.

Difficult to determine if Stockholmers experienced improved city environment

“City environment” is a complex and diffuse concept, and it is difficult to find a common, clear-cut definition of what is meant by good or improved city environment. It is also difficult to measure effects of this kind. Since “experienced improved city environment” was one of the targets of the Stockholm Trial, we have nonetheless tried, despite problematic data, to evaluate it. Conclusions from this study were not only obstructed by the above general problems but also by the completely different weather conditions that prevailed during the two measurement periods. Our interpretation below is thus characterised by a high degree of caution.

The results indicate experienced improvement for exactly those factors for which measurable changes can be demonstrated, that is those that were linked to reductions in traffic. In the city environment study, three improvements were experienced: better pace in traffic, better air quality and greater accessibility by car. The same tendencies appear in interviews made with cyclists in the inner city and with children who live in the inner city. The latter group’s experience of the city environment has very clearly improved, and many cyclists experience fewer cars in the inner city and that the traffic environment is better. The experienced changes for the worse mostly involve accessibility – by foot, public transport and bicycle. The results do not hold for any clear-cut or unambiguous assess-

ments of how the city environment has improved in general. A vital influence in the experience of accessibility by foot or bicycle was played by the weather and the season, which in our case differed from one measurement period to the other. The conclusion nonetheless is that effects that are clearly associated with changes in the traffic situation are also reflected in one's experience of the city environment.

Many ways of adapting to the new situation

If congestion charges were to be made permanent, both short-term and long-term adaptations would be made. Since the Stockholm Trial was merely a trial – and a short one – only short-term adaptations can be expected. It is only these short-term adaptations we can make measurements of and try to evaluate. In the long term there are other effects, such as localisation effects, which are discussed in the section on effects on regional businesses and commerce. There may also be other long-term adaptations on the individual level, for example part-time workers might decide in a somewhat longer perspective to redistribute their working hours so as to reduce the number of passages they make across the charge zone.

There is a multitude of strategies available for adapting to the new situation brought on by the Stockholm Trial. We have searched the evaluation material for features that are comprehensive enough to show up in measurements and analysis results. On the individual level there are of course even more variations than those we mention here. It is important to remember in a discussion of adaptation strategies however that it was only a small percentage of the county population's total journeys that were affected by the actual charge. The analysis of payers shows that a majority of inhabitants in the county paid at least a few times, and that a few motorists paid a lion's share of the congestion taxes. Approximately 4 percent of vehicles in the county – an equivalent of about 1.2 percent of the population – stood for a third of the congestion tax revenues from private vehicles.

There were two types of adaptations, which point in different directions. One way was to adapt so as to avoid the charges in one way or the other, which led to reduced traffic. Another was to adapt in a way that exploited the space freed up by the reduction in traffic volumes, which counteracted the traffic reduction. A further adaptation for avoiding the charges was to use a clean or eco-friendly vehicle, which – albeit marginally – reduced the environmental impact. Increased use of eco-friendly cars did not however reduce congestion. Since even the use of “eco-friendly” cars gives rise to negative environmental consequences, the congestion charge could reduce positive effects on the environment, if people with access to clear cars exploit available increased access to increase their own car travel. In the travel pattern study, there were no signs of such an effect.

That there has been a decline in car traffic, especially in the inner city, is entirely clear. Not only private motorists but those who drive commercial traffic seem to have adjusted their travel. According to the manual counts

of travel through the congestion-charge zone, there has been a 30 percent decline of private cars, 21 percent of light trucks and 13 percent of trucks.

The new park-and-ride facilities built for the trial have filled up on the whole, but it is not certain if this is because of a pent-up need or because of the congestion charges. It seems more likely that the increase in parking space at the approaches has been filled up as a result of the former, a pent-up need which has now been provided for. However the increase in the practice of parking-and-riding (about 2,000 cars a day) is almost negligible in relation to the number of cars across the charge zone (approximately 530,000 passages a day before the congestion tax) or the decline in traffic (approximately 100,000 fewer passages a day).

There is nothing however in the travel pattern study to show that car riders have changed the time at which they travel to any tangible degree, nor are there any signs that traffic increased during any period of the day as a result of the redistribution of traffic. In other words it was apparent that this was not a common way of adapting to the congestion tax, in contrast to indications from some studies on travel-time adaptation. Rather, people reorganised their travel to make it less frequent or more efficient, partly by changing their destination and partly by switching to other modes of transport.

Counts of the average number of people in each car have also shown that car pooling has not increased to any measurable degree. The average is a steady 1.27 people per car. Beside the counts, the travel pattern study also showed no affect of the trial on the number of passengers per car.

More than half of the approximately 80,000 car passages across the charge zone (not counting reduced passages of commercial traffic) that the county's inhabitants gave up as a result of the Stockholm Trial were journeys to and from work or school. Since telecommuting, distance work, car pooling/coordination have not increased, the conclusion is that these work-related journeys, previously made by car, were almost exclusively carried out using public transport instead. The remaining few have made a change in route, especially from previously having driven through the inner city to driving on the Essingeleden bypass.

It is interesting that the decline in car trips exceeds the number of public transport passages across the charge zone that were caused by the trial. Since public transport has not increased to the same extent that car travel across the charge zone has decreased, this must mean that certain trips across the charge zone simply go via other routes, to other destinations or are never undertaken as a result of the trial. Thus we can establish that the "amount of travel" in the situation before the trial is not a statistically fixed number that is to be replaced but that there is an adaptation potential consisting of travellers who plan their trips differently, leading to a decrease in the number of trips. This is a phenomenon that can be observed in analyses of normal seasonal variations also. A reduced frequency of car trips across the charge zone can also be discerned in the study of commuter trips from the Mälaren region to Stockholm's inner city and in the

attitude study, where fewer trips to the inner city are now reported. Considerable changes in heavy goods traffic (as shown in the manual counts at the approaches) also correspond with this reasoning and with reports of route planning and other information provided by transport companies.

Adaptations in the form of benefiting from freed-up space on the roads appears for example in the study of work journeys to and from two of the larger workplaces in the area. Among these commuters there was a greater number who didn't need to cross the charge zone who chose to drive during the peak period. Among commuters who both lived and worked outside the zone there was a slight increase in the percentage who chose a car as their means of transport. Another example is that since there was a decline in traffic in the inner city compared to across the charge zone, people chose to drive on the Klarastrandsleden bypass, now that it was possible to get through there. Not only the congestion tax itself has had an effect but also the improved access in and around the inner city. There were in other words many who didn't pay but who nonetheless were able to take advantage of the improved access.

As a result of significant seasonal variations between different groups and travel relations, no effect of the Stockholm Trial on such groups and relations in the travel pattern study can be distinguished.² The change from autumn 2004 to spring 2006, as expected, is primarily due to middle-income commuters making the change from car to public transport. This is also the pattern for foreign-born commuters and people with children. The fact that it is primarily people with middle incomes who normally make the change is explained by the fact that low-income earners are often already taking public transport and that high-income earners do not have as strong an incentive to induce them to decrease their driving.

It is likely that the trial with the congestion charges reinforced an upward trend in cycling in Stockholm's inner city. The underlying reason is the substantially expanded infrastructure for cyclists in Stockholm. The results however are neither dramatic nor entirely clear-cut or certain.

The attitude turned more and more positive as people experienced the effects

Both the general public and the business community became more positive to the charges and to the trial as time went by and they experienced it on their own and saw the benefits. Essentially, changes in acceptance normally look like this: Before you've experienced something yourself, you mostly see obstacles and expenses, but after you've made your own experiences, you begin to see the advantages and benefits you're getting for your money. There is still great uncertainty however as to how fast these changes in attitudes take place.

² Seasonal variation and congestion tax effect can be discerned in the traffic counts – but they do not answer the question of *how* travellers changed their travel, only *how much* of a decline there was of the total car traffic.

The percentage of county inhabitants towards the end of the trial who thought there were problems with congestion have declined compared to before the introduction of the congestion tax. The proportion who experienced serious problems with congestion has been halved, from 40 percent to 20 percent. If we include those who experience some problems with congestion, the proportion has declined from 73 percent to 52 percent. The respondents' subjective perception of congestion is in agreement with the results from the congestion measurements. For example there was a traffic increase and subsequent congestion increase during the period from May to June due to the variation in season ("spring leap") – with a subsequent increase in the proportion of respondents who felt congestion was a problem during the period.

The attitude to the trial has also become more and more positive as the trial has proceeded. In autumn 2005 approximately 51 percent of all county inhabitants felt that it was a "fairly/very bad decision" to carry out the trial with the congestion tax. Since the congestion tax was introduced in January, this proportion has fallen steadily. In May 2006 54 percent felt it was a "fairly/very good decision," while 42 percent felt it was a "fairly/very bad decision." Those who had travelled by car to and from the inner city over the past two days were more negative towards the trial than county inhabitants in general, but even this group had become more positive during the period by several percentage points. These changes were observed in several studies on different groups of county inhabitants.

Many inhabitants themselves report that their attitudes have changed during the trial. In May, 35 percent felt they had become more positive to the congestion tax as compared to in the beginning of the trial, while 15 percent felt they'd become more negative. The remaining percentage had not changed their view.

Just as for the rest of the population, owners of businesses have changed from being predominantly negative to being more positive, both to the trial and to the congestion tax as a permanent measure. The change is more notable for the trial itself than for the congestion tax as a permanent fixture.

Companies are unanimous however, as far as we can see, in their criticism of the inconveniences and administrative costs brought upon them by the charge system itself. There have been insinuations that companies really still think the system is an obstacle to growth, but before the trial the view was that *both* one's own company and other companies would suffer while now business owners are more restrained in their assessment of their *own* company's negative development.

In the attitude surveys, it can be seen very clearly that the reason for driving a car during the trial compared with before the trial more often is that you save time compared to other modes of travel. Among those who took public transport we can see a decrease in the number who chose it because of too much traffic and queues. This is interesting because it means

that the improvements in accessibility that could be measured with objective means have also been perceivable “with the naked eye.”

We can also conclude that public transport passengers appear very pleased with the direct bus lines.

Drivers of company cars are a group whose adaptation pattern has been more difficult to assess than other groups’, due to the fact that the cost of the congestion tax for private trips was sometimes picked up by the employer, sometimes paid by employees themselves. There was also a half-way-between variant, where the employee paid through a so called gross-salary deduction, which meant that the actual cost of the congestion tax became significantly lower. According to the attitude survey, employers paid the congestion tax in 13 percent of the cases, while 4 percent said they paid themselves just as often as the company.

It is reasonable to assume that those driving company cars had a lower average expense for passing across the charge zone than the usual private motorist. We would also expect that company car drivers, because of higher average incomes, would be less sensitive to prices. Indeed the manual counts of entrance traffic showed a higher proportion of company cars across the charge zone.

The technical system works

We would very much have liked to include an assessment of how well the technical system in itself worked, but since we have no evaluation to refer to at present, we can only make a general assessment. We are aware that this prevents us from being able to determine how troublesome the charge system was for isolated individuals or organisations.

It can be concluded, however, that on an average day in May, 371,300 passages took place across the charge zone, leading to 115,100 tax decisions and a revenue of over SEK 3 million. Of the 115,000 tax decisions, 100 were asked to be reviewed by the Swedish Tax Agency and 5 were appealed to the Stockholm County Administration Court. On such an average day in May, the customer service department at the Swedish Road Administration received 2,200 calls. On the basis of these figures, our assessment is that the system worked well on the whole. The case studies that were made indicate that certain adjustments in the system are required to reduce cumbersome administration for companies.

There is reason to note that the cost of inconveniences to both private people and companies are lacking from the cost-benefit evaluation. It is plausible that many people felt the inconveniences were greatest in the beginning and then experienced a decline as they learned the easiest way to pay.

Benefits and costs distributed unevenly

Charges in the traffic system always mean that different groups are affected differently by the direct and indirect effects of the charges. This

applies to practically all changes in the conditions of an existing traffic system. There are those who gain from the change and those who lose. This is often expressed in terms of a measure afflicting different groups differently, by which it is easy to imagine that every individual has a firm group affiliation and that all individuals in a certain group are afflicted similarly. Reality is far more nuanced. Even if certain types of group affiliation seldom change, such as income bracket and type of household, other types of group affiliation may change more often. Most people, for instance, are sometimes passengers on public transport, sometimes cyclists and sometimes motorists.

As a motorist, time is sometimes what you value the most but in other situations it might not feel the least bit important. Sometimes it's extremely important to get where you're going fast and you are willing to pay for it, while at other times speed is not a high priority at all.

Many of the distribution effects have to do with the very idea behind congestion charges, which is to redistribute road space efficiently – that is to those who value it the most, which is different people at different times. This aspect is, however, difficult to measure, which means it is not included in the cost-benefit assessment. That the assessment omits the fact that individuals' so called time valuation can differ from occasion to occasion means that it underestimates the total benefit to society signified by the congestion tax.

Essential winners from the congestion charges were:

- those public transport passengers who received a larger selection of services
- those who were exempted from charges
- those who drove a car without driving across the charge zone and thus achieved shorter travel time at no cost
- cyclists (seem to have received a better traffic environment)
- those who value their time and feel a time gain is worth the money
- commercial drivers (bus drivers, taxi drivers, truck drivers, etc., who received a better work environment)

Essential losers from the congestion charges were:

- those who drove a car across the charge zone and for various reasons could not adapt their travel, but still don't think the time gain was worth the money
- those who were "forced off" the roads
- those public transport passengers who experienced more crowding in public transport

In discussing how different groups are affected it is also important to remember that this applies to *the whole group*. The *individual* who paid the

congestion tax for a passage has the same cost in hard cash regardless of his or her group affiliation. The follow-up studies present average effects on different types of groups – but even variation *within* a group is large. Even in groups where the average payment of congestion tax is very low, there are individuals who pay quite a lot in congestion tax. And vice-versa, in groups where the average payment is high, there are individuals who seldom pay any congestion tax.

How the revenue from the congestion tax is used is crucial to what the distribution effects will be, that is which groups “gain” and “lose,” generally speaking. The difference in distribution profile between possible revenue uses is often greater than the difference in distribution profile for the actual congestion tax.

A large percentage of the county’s motorists paid congestion tax at least every now and then. In a two-week period, almost half of the owners of private cars in Stockholm County paid congestion tax at least once. In total there were fairly few who paid a high amount of congestion tax; only about 1.2 percent of county inhabitants reached a total cost of SEK 200 or more during a studied two-week period.

The groups that paid the most congestion tax on average per person are men, high-income earners, married couples/cohabitants with children and residents in the inner city and in Lidingö.

Those who paid the most congestion tax are inner city residents. At the same time they had the least direct benefit from the improved travelling times (since the greatest gains in travelling time were on the way to the inner city in the morning and away from there in the afternoon). The cost-benefit analysis thereby points out the inner city residents as the greatest losers from the congestion tax. Nonetheless it was they who had the most positive attitude towards the tax, according to the opinion surveys. This is interesting to note, and to speculate upon as to why their opinions didn’t agree with the prediction of the calculation. Perhaps this is due to the phenomenon mentioned above, that the few times “seldom-drivers” use their car, it is a time gain they value more than the average motorist would do. Or perhaps it is because factors that are difficult to rate were underestimated in the calculation, like improved environment and increased road safety.

As opposed to private motorists, both business trip travellers and commercial drivers – as groups – were regarded as net gainers even *before* they received anything from revenue distribution. The value of gaining in travelling time is thus higher than paid congestion tax for commercial traffic and business trip travellers. Private motorists on the other hand paid on average more congestion tax than the time gain is calculated to be worth and are thereby net losers. Since both private and commercial traffic paid the congestion tax, while the revenue was a contribution to income tax financed operations only, a certain transfer of resources from commerce to resident was achieved.

Furthermore it is interesting to observe that over 60 percent of the gains in travelling time in the cost-benefit analysis comes from commercial and business-related traffic, despite the fact that such traffic constitutes only slightly more than 35 percent of the traffic across the charge zone.

Marginal affect on regional trade and commerce

Regional trade and commerce can be affected both in the long term and the short term. The effects on the economy depend to a great extent on if – and how – the charges are returned to the region. The effects of the Stockholm Trial on the business community have been investigated in several studies. Above all a comprehensive economical analysis of the state of the market and commerce development in the county has been made. Other studies include investigations of trade, visit-intensive activities, contractor companies, driving schools, refuse collection transports, distribution traffic, taxis, transport services for people with disabilities and delivery and collection transports. What is obvious is that the business community is dependent on a well-functioning road transport system.

The short-term influence on commerce and other business sectors that were studied shows only minor average effects. These effects often disappear among other factors with greater impact, such as newly established businesses in the commerce sector. The turnover surveys that have been done indicate that the Stockholm Trial has had little effect on the retail trade in the region. The study of sales of consumer durables in shopping centres, galleries and department stores during the period shows that they developed at the same pace as in the rest of the country. The conclusion cannot be drawn that the Stockholm Trial has had a negative influence on small-scale businesses as a whole within the charge zone, but this is not the same thing as saying that individual workplaces or companies were not adversely affected.

The information available to us for assessing the long-term effects on companies is how the companies themselves view their future actions.

Earlier experiences, such as those in London, indicate that congestion charges yield small effects compared with the regional economy as a whole. Normal variations in the economy are generally larger than the impact from congestion charges. The Stockholm Trial's contribution to total production in the county was 1 of SEK 750 billion. In most cases the congestion tax had only a marginal effect on companies' total transport expenses. For households, the congestion tax according to the Stockholm Trial's model during one year corresponds to approximately 0.1 percent of combined disposable income. This means that purchasing power in the county was not influenced markedly, even if the tax may have had significant consequences for individual households.

In regard to model calculations of changes in an area's attractiveness, they are very sensitive to which time values – hard cash for what you think time is worth – are assumed. The analysis not only shows only very small changes but they are also uncertain, depending on the sensitivity of the

assumptions made. The changes are also small in comparison with the general increased pressure from an increasing number of inhabitants and workplaces in the region. The influence of housing prices has little effect as well. The model-calculated long-term effects are not greater than the normal price variation between two quarters of the year.

Congestion charges are (macro)economically profitable

A (macro)economic analysis is a way of systematically trying to summarise a measure's total effects and costs. The analysis is made as an attempt to determine whether the measure was "worth the money," that is, whether the values it created for society were greater than the cost.

The Stockholm Trial – seen as something brief that is over and assuming it will not be resumed – constituted an economic loss of about SEK 2.6 billion. Initial investment and subsequent operation of the congestion tax system make up the greater part of the loss. This does not include the value of experience and research however. This particular perspective is of limited interest; the fact that the investments were not recovered during the trial period is not surprising.

A permanent implementation of the congestion tax system is calculated to yield a significant annual cost-benefit surplus, about SEK 760 million (after deductions for operating costs). The congestion tax system's investment cost after four years would be "repaid" in the form of benefits to society. That is a very short repayment time compared for example with road or public transport investments, which in moderately favourable cases "pay off" in economic terms in 15-25 years. From the viewpoint of benefit to society, the most relevant decision perspective is to ignore the investment cost – the trial cannot be undone and the investment money is spent and gone. But the congestion tax is economically profitable even if the cost of investment is taken into consideration.

The cost-benefit surplus of the congestion tax consists, among other things, of shorter travelling times (worth SEK 600 million annually), increased road safety (SEK 125 million annually) and health and environment effects (SEK 90 million annually). The revenue from the congestion tax is estimated to be about SEK 550 million annually (when the system's operation costs are deducted). For every *krona* collected in congestion tax, there is a cost-benefit profit to society of a further .90 *krona*.

The expanded bus service is estimated to be (macro)economically unprofitable, both during the trial and if it were to be made permanent. The benefits are expected to be in the region of up to SEK 180 million annually, compared with a economic cost of operation of SEK 520 million annually. The result should be interpreted cautiously however; it is not unusual that public transport is calculated as economically unprofitable in a narrow meaning but is nonetheless considered to be important to carry on for other reasons.

Environmental effects in the form of road safety, climate and health are worth slightly more than the cost to road users in congestion tax for vari-

ous kinds of sacrifices. The price level and evaluation of both road safety and the environment are characterised by considerable uncertain factors. This uncertainty is not good of course, but it has no decisive role in the total (macro)economic analysis of the trial.

Cost-benefit analyses consider the average effects on all individuals in a society. For particular individuals the consequences of the congestion tax can be both positive and negative. What the net effect is for different individuals depends to a high degree on how the revenues from the system are used.

Based on older research about the health effects of traffic, the congestion tax emerges above all as an accessibility measure. It is improvements in accessibility that create the greatest cost-benefit values. Health effects are estimated to be low compared with the value of increased accessibility when based on these slightly older connections between emission and health. If instead we were to use the latest research about the health effects of traffic, there would be an increase in the congestion tax's health benefits. The total value of environmental and safety improvements would be almost twice as much.

Discussion

Major effects compared with other measures

A decline in car traffic when it becomes more expensive to drive is hardly surprising. That said, an interesting question is how great the effects of the Stockholm Trial have been compared with other kinds of measures. The answer is that the decreases in traffic flow and travelling times are great compared with other measures that have been implemented or discussed for implementation in Stockholm traffic. The following are examples:

- A new easterly connection between Nacka and the inner city (the so called Österleden bypass) is expected to reduce the number of cars over the inner city bridges by about 14 percent. A corresponding decline for a new westerly connection (Diversion Stockholm) is estimated at about 11 percent.
- The rise in petrol price of just under SEK 1 (9 percent) that took place between April 2005 and April 2006 is estimated to have reduced car traffic through the congestion zone by a little less than 3 percent.
- Introducing travel at no cost on Stockholm's public transport is estimated to reduce vehicle kilometres travelled – the total distance covered – in the county by 3 percent.

We should also remember that traffic investments are expensive and take a long time in construction. Many desirable investments in Stockholm traffic are in fact in the multi-billion division. For example Diversion Stockholm is expected to cost about SEK 20 billion and the City Track (commuter tunnel) about SEK 14 billion. Since the congestion tax, after deductions for operation costs, yields instead a surplus of SEK 500-600

million annually, it is unreasonable to set investments *against* the congestion tax, as if they were comparable substitutes for each other. Both economically and from the viewpoint of traffic, it is more natural to think of them as complements.

At the same time it is important to point out that the congestion taxes – even if the net profit to society is positive – represent a sacrifice for many people. These sacrifices need to be weighed against the advantage of accessibility and environmental effects brought on by the tax.

The significance of the trial as such

The Stockholm Trial has brought with it a unique collection of data about traffic and its effects on Stockholm. Knowledge and skills in the field have thus increased. In the following we will present some of what has been learned.

For example it is now established that travelling time improvements have become so obvious that the general public not only acknowledges them but expresses appreciation of the improvement. A valuable lesson of the trial is also that travelling time improvements spread out far from the inner city, a fact that was not known previously.

The decline of truck passages across the charge zone were not surprising to us. For future use it would have been of value to have been able to express in more detail how commercial traffic adapted to the congestion tax.

Many of us – although not all – are surprised that not more than half of the car trips that disappeared from the statistics were replaced by public transport. This is a sign that the number of trips is not a fixed figure that can be distributed over various destinations, modes of transport or hours. Even if an adaptation of start time for journeys can be discerned in several of the studies, the heavily reduced number of car trips clearly shows that this adaptation strategy is of a lesser proportion. A further factor that points in this direction is that the Essingeleden bypass managed as well as it did.

Adaptation to the charges occurred, and occurred quickly. Before the trial – and especially when it became clear that the trial period would be shortened to six months – there was speculation as to whether this would mean that no evidence of traffic reductions would be forthcoming. Would people simply regard the trial as so short and fleeting that it wasn't worth changing one's behaviour but just put up with it during the trial period without adapting their travel behaviour? Now we know that this type of measure has immediate effects.

As it is not possible to see any direct impact on commerce and other business, the trial has shown that travel can be reduced without influencing economic growth, so called decoupling.

The Stockholm Trial provides interesting knowledge about how toll systems should be designed, which is of benefit to other cities as well. One

question that has long been discussed among traffic economists is to what degree a zone toll of the kind used in Stockholm is sufficient for regulating traffic in a whole city. After all, traffic conditions vary from street to street and minute to minute. When the zone is as large as the one in Stockholm, there is a risk that even if significant effects occur on travel across the zone boundaries, the streets within the zone would be filled up by motorists who are already inside the zone and who increase the amount of their travel when they see that streets are more accessible. For several years before the Stockholm Trial there were discussions of alternative solutions, such as several different zones with varying charges. None of the existing toll systems are well suited to elucidating this issue. In London only a minor area in the central city is involved, in Singapore the access to cars is also regulated, and in Oslo and Bergen the system is aimed at affecting traffic as little as possible. The Stockholm Trial confirms that a simple zone toll yields marked effects within a large area.

In the face of a possible permanent implementation of the congestion tax there is reason to discuss how the charge should be designed and differentiated. We feel for example that the charge period could be shortened somewhat in the morning. There is also reason to consider whether the charge levels should vary depending on the seasonal variation that exists in traffic. We do not have a definitive answer to the question of whether it is good from a traffic point of view to exempt the Essingeleden bypass. Even if there has not been marked decline in accessibility on the bypass during the trial period, increased traffic there would mean increased vulnerability to disturbances in the traffic system as a whole.

It is now also entirely obvious that expanded public transport was not an effective measure against road congestion on its own. The investment in public transport in itself does not seem to have yielded a decline in car traffic at all – travel on public transport may have increased, but the effect is extremely uncertain. Well-functioning public transport on the other hand is a necessary precondition for handling the increased number of public transport passengers.

What can be changed if the charge system is made permanent?

A system's design is influenced by what it is primarily hoped to achieve. It is very important to determine for instance whether the main goal is to reduce congestion or to reduce the environmental burden from traffic. If there is to be a permanent implementation of the charges for Stockholm traffic the goals for what is hoped to be achieved in the short run and in the long run need to be discussed and carefully formulated. From the viewpoint of benefit to society the charges should be regarded primarily as an instrument for overcoming congestion.

The relatively simple charge structure, with a charge circle, has not caused any dramatic differences in goal fulfilments from one place to another. However there is now knowledge available that can be used *if* a more complex charge structure were to be preferred. From a traffic view-

point it would be desirable to be able to vary the charge level during the year. Traffic in May-June is much higher than during the winter, dropping to a very low level during the summer. This means that the reduction in traffic required for good accessibility varies during the year. With a variable charge level, this could be regulated.

A goal level of a 10-15 percent reduction in traffic flow is probably on the low side for attaining good accessibility during certain hours in certain places. During May-June, when traffic is at its maximum, greater traffic reductions are needed to achieve really good accessibility.

The charge levels have on the whole been neither too high nor too low – or possibly on the high side – for achieving the effects desired.

It is hard to give a definitive answer to the question of whether the charge is needed for traffic reasons on the Essingeleden bypass when the inner city is imposed with a charge. Up to now accessibility has been more or less unchanged compared with last year, but the traffic burden is so high that even small changes in traffic flows could have a great effect on accessibility.

Charges can strengthen Stockholm's attractiveness

For many cities, attractiveness is a crucial issue for development and survival in the future. From time to time it has been said that congestion charges have a negative effect on attractiveness. It could be worthwhile to point out however that in other places in the world, serious accessibility problems are considered to be obstacles to certain things in the city, such as business life, and that this reduces the cities' attractiveness.

In many urban areas around the world, congestion and environmental impact are obstacles to continued sustainable urban development. Congestion charges are presently being discussed in a large number of European cities and many of them are following the developments in Stockholm very carefully. In the USA there have recently been decisions on the federal level to implement a large number of trials with this type of charges. In all of these cases the view of congestion charges is not merely as a method for increasing accessibility but also as a way for cities to retain their attractiveness and to continue to develop, for the benefit of citizens and business life alike. As an example we could mention that Kathryn Wylde, managing director for Partnership for New York City, a network of business leaders in New York, at the international conference "Voices on the Stockholm Trial" put forward that the business community in New York regards congestion charges as a prerequisite if New York is to continue to be attractive in a way that makes it possible for businesses to grow and flourish.

Research in recent years shows that a city's appeal is vital to attracting a labour force, which in turn attracts businesses and generates growth. From this perspective the trial and the system's possible permanent status could increase Stockholm's attractiveness.

Presentation of Members of the Analysis Group

Staffan Algers, who has a doctoral degree from the Swedish Royal Institute of Technology, works as a senior consultant at Transek AB. He is an internationally established researcher with long experience of developing and applying traffic prediction models and has headed several major model development projects. Mr. Algers is also an adjunct professor at the Royal Institute of Technology at its Unit for Transport and Location Analysis.

Karin Brundell-Frej is a senior lecturer at the Department of Technology and Society at Lund University, from which she got her doctoral degree. The main focus of her research is on analyses of traffic demand and modelling, road safety analysis, and transport and the environment.

Jonas Eliasson has a doctoral degree from the Swedish Royal Institute of Technology and works as an analyst and consultant at Transek AB. His research has primarily focused on valuation studies, national economy, and transport and land use models.

Cecilia Henriksson, who has a licentiate degree from Stockholm University, is the managing director of the analysis and strategy company Inregia AB. She has many years' experience of investigational and statistical projects in the field of regional development and is a specialist on investigations and strategic advisory services for trade and commerce.

Lars Hultkrantz is a professor of economics at Örebro University and scientific advisor to the Swedish National Road and Transport Research Institute (VTI). Prof. Hultkrantz is also a member of the Royal Swedish Academy of Engineering Sciences.

Christer Ljungberg, with a licentiate degree from Lund University, is managing director of Trivector Traffic AB. The main field of his research is sustainable transport systems. He has participated in and headed a large number of research projects on public transport, cycle traffic, transport strategies, etc. Ljungberg is also a member of the Swedish Urban Environment Council.

Lena Nerhagen is employed as an assistant professor at Dalarna University and as a researcher at VTI, the Swedish National Road and Transport Research Institute. She has a doctoral degree from Göteborg University and specialises in transport and environmental economics. At present the focus of her research is on health effects of transport-generated particles and how they can be evaluated.

Lena Smidfelt Rosqvist has a doctoral degree from Lund University and is employed as a traffic investigator at Trivector Traffic AB. Her field of expertise is combined environment and traffic planning and traffic evaluations. In addition, Smidfelt Rosqvist is a programme manager at TransportMistra.

Evaluation reports

1. Road Traffic

1.1 Road Traffic analysis

This report presents the results of the analysis of the major road traffic measurements conducted by the City of Stockholm Traffic Office on four occasions (autumn 2004, spring 2005, autumn 2005 and spring 2006) in connection with the Stockholm Trial. In addition, information is used from continuous traffic measurements from September 2005 up to and including April 2006. The purpose of the report is to provide the necessary data to enable decision-makers to make an informed decision about whether the objectives of the Stockholm Trial have been achieved, and whether the traffic effects recorded depend on congestion charging. The traffic objectives are:

- to reduce the number of vehicles passing in and out of the congestion-charge during the morning and afternoon/evening peak periods by 10–15%
- to improve the flow of traffic on the busiest roads in Stockholm.

This report also serves as one of several documents that provide a basis for the evaluation of the two other objectives of the Stockholm Trial, which relate to reduced emissions and an improvement in the urban environment.

Weekday traffic

The congestion-charge zone includes all approach and exit roads to and from the Stockholm inner city area. A comparison between spring 2005 and spring 2006 shows a sharp decline in the number of vehicles passing the congestion-charge cordon. During the congestion charge period (06.30–18.29) the reduction was 22%. The reduction during the morning peak period was somewhat lower (16%), while the reduction during the afternoon/evening peak period was somewhat greater (24%). Measured over a full 24-hour period, there was a 19% decline in the number of vehicles passing the charge cordon in spring 2006 compared with spring 2005. This equates to approximately 100,000 fewer passages.

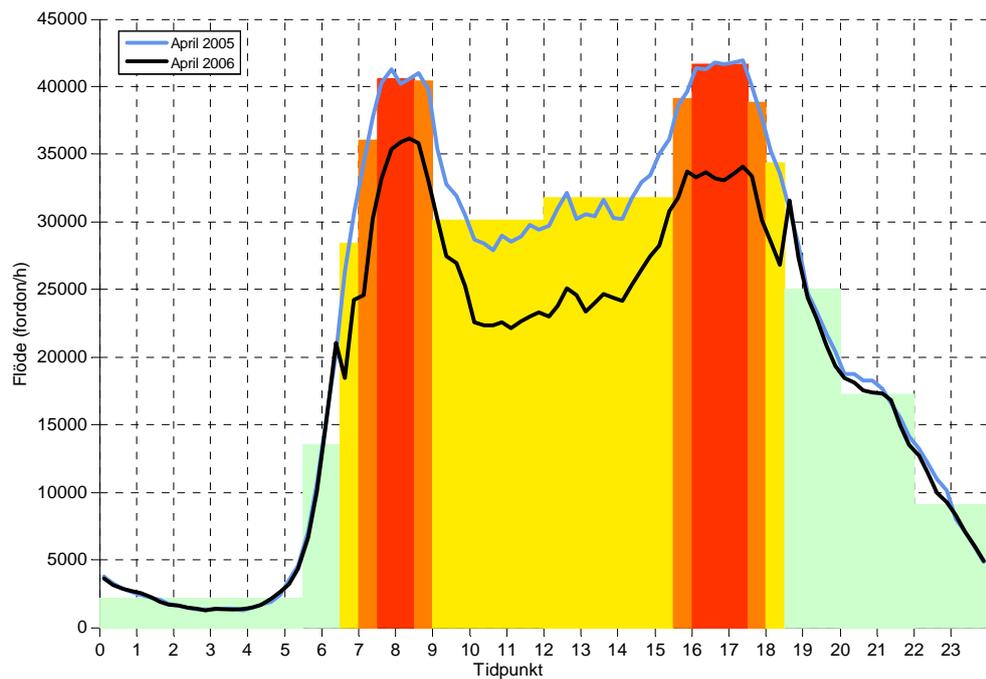


Figure 3: Traffic passing in and out of the inner city on an average day in spring 2005 compared with spring 2006. The areas below the curve that are shaded green mark the charge-free period. The yellow, orange and red bars show the periods during which a charge of SEK 10, SEK 15 and SEK 20 respectively is levied.

/Translation. Figure 3/

Flöde (fordon/h) = Flow (vehicles/h)

Tidpunkt = Point of time

Figure 3 compares traffic levels in spring 2005 and spring 2006. The morning and afternoon/evening rush-hour periods are visible in the form of two distinct peaks. By spring 2006 traffic had declined by approximately 22% during the congestion-charge period compared with figures for spring 2005. However, the traffic situation in the hours preceding and following the charge period remained more or less unchanged. That the reduction in traffic was less marked during the morning peak period than during the remainder of the charge period is probably due to the fact that the majority of journeys made during the morning peak period are travel to work, which is generally subject to more rigid time restrictions than other forms of travel. The reduction in traffic was greatest in the middle of the day and during the afternoon/evening peak period. This is probably because traffic at these times is, to a greater degree than in the morning, generated by journeys that are more flexible in terms of time and destination.

Minor peaks in the traffic curve (in Figure 1) for spring 2006 that occur immediately before and immediately after the charge period indicate that a limited number of drivers have opted to adapt their departure times to

avoid paying the charge. In other words, they make sure that they pass the control points immediately before or immediately after the charge period.

Figure 4 below shows the distribution of traffic on the various approach roads to the inner city area of Stockholm.

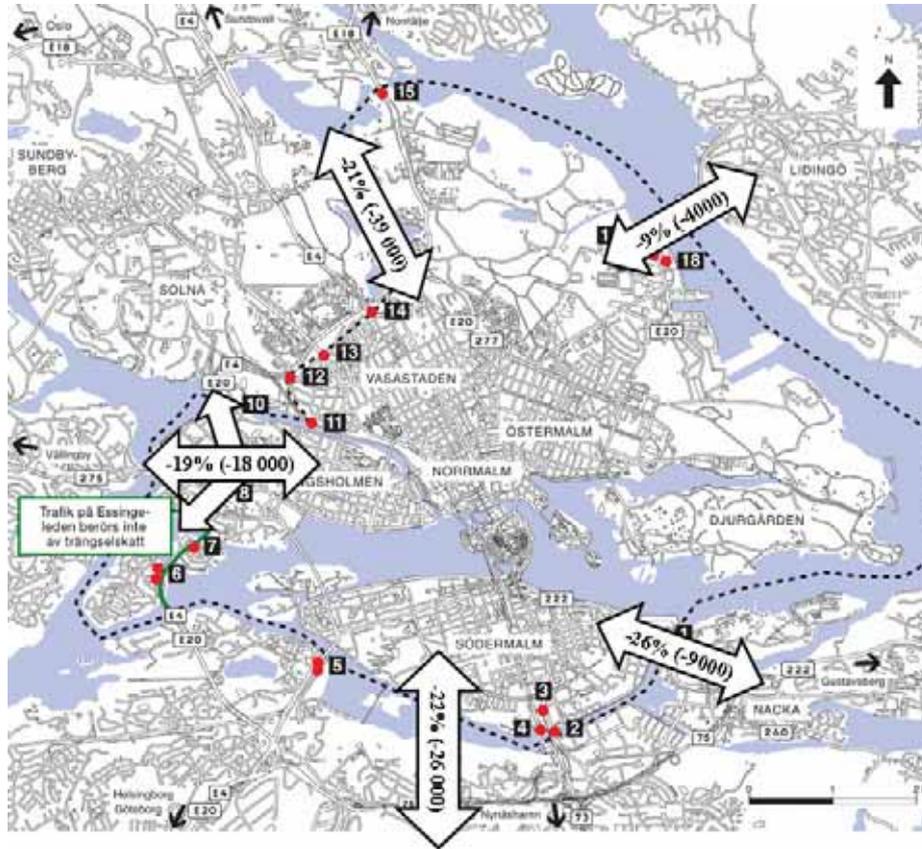


Figure 4: Percentage change in traffic flows in and out of the congestion-charge zone during the charge period (06.30–18.30) for different points of the compass. (The figures in parentheses indicate the change in the number of vehicle passages.)

/Translation. Figure 4/

Textbox: Traffic on the Essingeleden bypass is not subject to congestion tax

In percentage terms the reduction in traffic is greatest along the south-eastern approach to the city (Danviksbron) and smallest on the approach from Lidingö (north-east). It is no surprise that traffic from Lidingö shows the smallest reduction: road-users from Lidingö travelling to destinations outside Stockholm inner city are exempted from having to pay the congestion tax (as are those travelling from destinations outside the inner city to Lidingö). One possible explanation why the greatest reduction in traffic is via the south-eastern and southern approaches to the city may be that these routes have previously been used by a greater proportion of through traffic, and that these drivers now choose to avoid paying the congestion tax by using the Södra Länken-Essingeleden corridor to by-

pass the inner city area. The reduction in traffic from the west is slightly smaller.

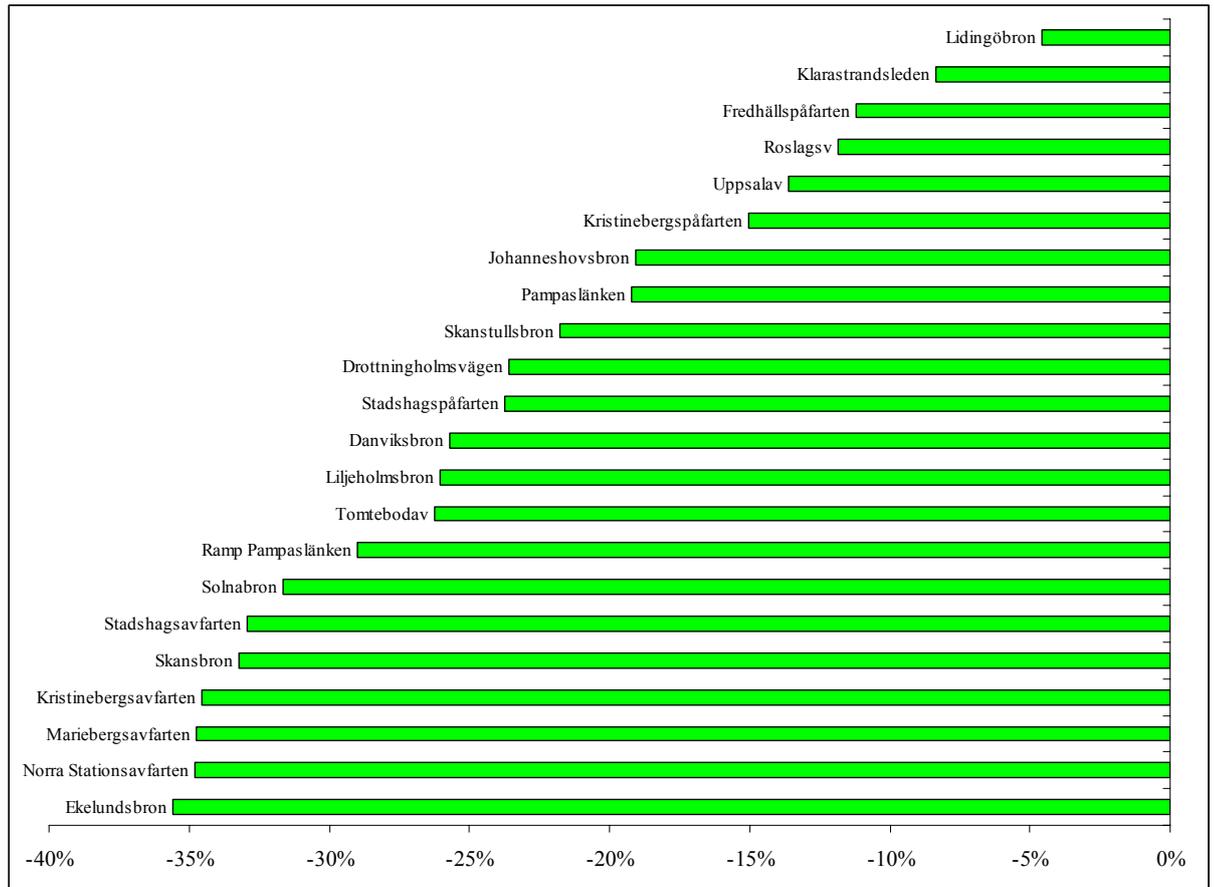


Figure 5: Percentage decline in traffic on the approach roads to the Stockholm inner city area during the charge period (06.30–18.30).

Figure 5 shows the percentage decline in traffic on roads to and from the Stockholm inner city area during the charge period. The reduction on the various approach roads varies between approximately 5% from Lidingö and approximately 36% via Ekelundsbron.

Table 1: Change in traffic in spring 2006 compared with spring 2005 on selected stretches of road in Stockholm.

	Morning peak (07.00-09.00)	Afternoon/ evening peak (16.00-18.00)	Charge period (06.30-18.29)	Full 24 hrs
Congestion charge zone	-16%	-24%	-22%	-19%
Major inner city streets: <i>e.g. Vallahallav, Strandv, St Eriksg, Hornsg, Folkungag, etc.</i>	-7%	-10%	-10%	-7%
Smaller inner city streets: <i>e.g. Norrlandsg, Lindhagensg, Scheeleg, Katarinav, etc.</i>	-8%	-13%	-10%	-8%
North-south axis/inner city through-routes: <i>e.g. Söderledstunneln, Centralbron Bridge and Klarastrandsleden</i>	-2%	-10%	-12%	-8%
Outer approach roads: <i>e.g. Nynäsv, Solnav, Huddingev, Stocksundsbron Bridge, etc.</i>	-3%	-4%	-5%	-5%
Outer link roads: <i>e.g. Bergshamravägen, Örbyleden, Magelungsvägen, etc.</i>	4%	4%	1%	0%
Outer-city roads: <i>e.g. Gamla Tyresöv, Skärholmsv, Lugnets Allé, Skälbyv, etc.</i>	-5%	-4%	-5%	-5%

A comparison between figures for spring 2006 and spring 2005 shows that traffic on major streets in the inner city area (Valhallavägen, Strandvägen, etc.) has declined by approximately 10% during the charge period. On smaller streets (Norrlandsgatan, Lindhagensgatan, Scheelegatan, Katarinavägen, etc.) the overall decline is more or less the same as for the major streets (just over 10%), albeit with slightly greater reductions during the peak periods. The reduction is not as great as the reduction in traffic to and from the charge zone. This is to be expected, however, given that inner city traffic includes vehicles driven by residents, delivery vans, etc., which do not leave the charging zone. Moreover, no congestion tax is levied on journeys totally within the charge zone. As a result, the peaks in traffic during the morning and afternoon/evening rush hours are less marked than they are for traffic travelling in and out of the inner city area. As elsewhere, the reduction in traffic within the charge zone is greatest around the middle of the day and during the afternoon/evening peak period.

For the north-south axis route that includes Söderledstunneln, Centralbron Bridge and Klarastrandsleden a similar pattern emerges as for the major streets in the inner city. The reduction in traffic during the charge period is approximately 12%. On the other hand, the reduction is considerably smaller during the morning peak period, when traffic volumes are virtually unchanged compared with spring 2005. The very small reduction in traffic along the north-south axis route during the morning peak period is probably due to improved access. Improved access means that the traffic flows better, and, as throughflow improves, the route attracts an increased amount of traffic. There has even been an increase in traffic travelling north-west out of the city along Klarastrandsleden during the morning. One possible explanation for this is the reduction in northbound traffic from Essingeleden via Eugeniattunneln and the Norra Länken link, opening the way for more vehicles from Klarastrandsleden to use the available capacity freed up in the road network, as the throughflow of traffic improves.

Approach roads from the suburbs along Nynäsvägen, Solnavägen, Hudingevägen and Stocksundsbron Bridge, etc. (described here as “outer approach roads”) show distinct peaks in traffic volumes during the rush hour. On average, traffic has declined by approximately 5% over the charge period as a whole. The greatest reduction has been measured on Solnavägen (approximately 18%). That the reduction is considerably less than the reduction in traffic passing the charge cordon is due to the fact that only part of the traffic on the outer approach roads has its starting point or destination within the inner city area. Traffic has also declined on approach roads even further away from the city, which shows that the effects of congestion charging extend far beyond the charge zone itself.

By and large, however, congestion charging has not had any effect on the traffic situation on the city’s outer link roads (roads such as Bergshamravägen, Örbyleden, Magelungsvägen, etc. that connect two or more important areas). Traffic has increased on some of these link roads, and decreased on others. Generally, however, traffic flows have been the same in spring 2006 as they were in spring 2005.

On the other outer-city streets, such as Gamla Tyresövägen, Skärholmsvägen, Lugnets Allé and Skälbyvägen, traffic has declined on average by approximately 5% between spring 2005 and spring 2006. This reduction is spread fairly evenly throughout the day, although here too, there are relatively large variations between different roads.

Traffic on Essingeleden has increased somewhat from spring 2005 to spring 2006. The rise varies between 0 and 5% depending on the monitoring site. This difference is relatively small, bearing in mind that traffic on Essingeleden normally varies by a few percent up or down from week to week.

Table 2: Change in traffic in spring 2006 compared with spring 2005 for the E4 European highway and the Södra Länken bypass tunnel.

	Morning peak (07.00-09.00)	Afternoon/ evening peak (16.00-18.00)	Charge period (06.30-18.29)
Södertäljevägen (monitoring point: Solberga)	-1%	-3%	-3%
Södertäljevägen (monitoring point: Midsommarkransen)	-3%	-3%	-3%
Essingeleden (monitoring point: Gröndalsbron Bridge)	0%	4%	5%
Essingeleden (monitoring point: Hornsberg)	-5%	-5%	-1%
Uppsalavägen (monitoring point: Frösundabacke)	4%	3%	1%
Sickla Kanalbro Bridge	16%	19%	18%
Södra Länken	21%	12%	19%
Södra Länken towards Essingeleden	15%	23%	26%

There has been a steady increase in the numbers of vehicles using Södra Länken since this bypass opened in October 2004. It frequently takes some time before investments in new infrastructure begin to achieve their full effect. During the first twelve months after the opening of the Södra Länken bypass, traffic increased by approximately 19%. Comparisons between spring 2005 and spring 2006 show a further increase of 18% during the charge period. It is, of course, impossible to determine exactly how much of this increase depends on the Stockholm Trial and how much is due to natural traffic growth. Another factor that needs to be taken into account is the considerable disruption to traffic caused by the “Lodbrok” accident during parts of the monitoring period in autumn 2005. However, most indicators suggest that the increased amount of traffic using Södra Länken is not an effect of the Stockholm Trial, but a natural consequence of the redistribution of traffic and of growth in traffic following the opening of new links in the road infrastructure.

Weekend traffic

The figure below shows the average traffic flow on Saturdays. As can be seen, there has been hardly any change in traffic since 2005, apart from on the E4 European Highway, where the number of vehicles has declined.

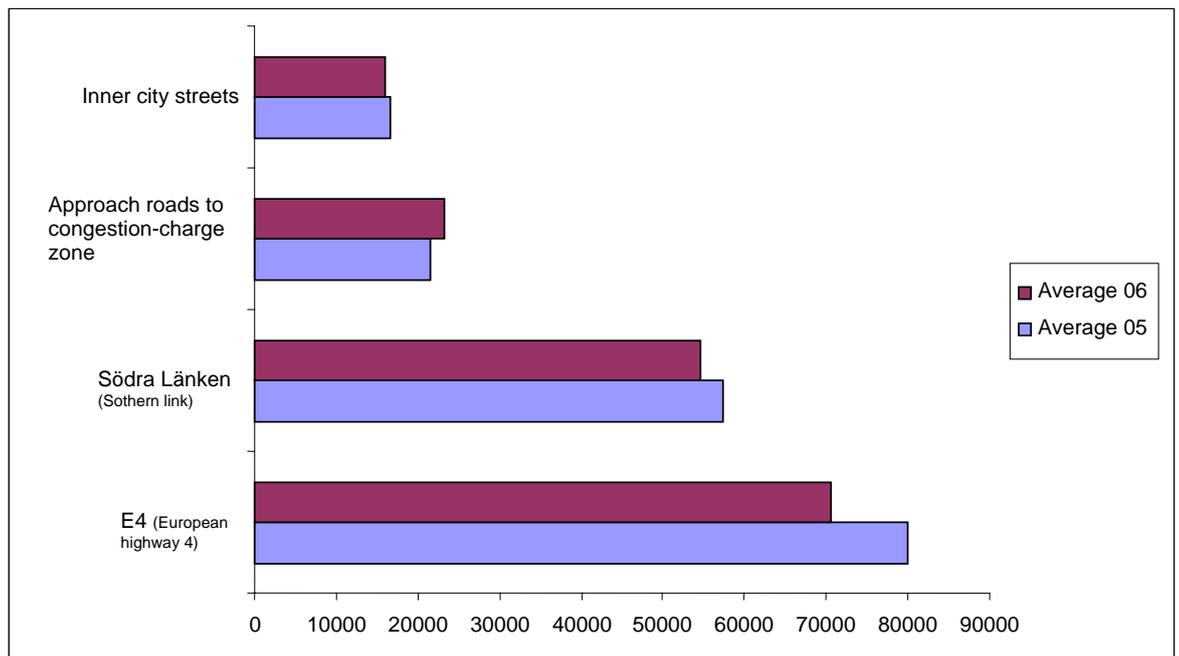


Figure 4: Average traffic flow on Saturdays in 2006 and 2005 on different categories of road.

Vehicle kilometres travelled (VKT)

Vehicle kilometres travelled (VKT) is the sum of distances travelled by all motor vehicles within a traffic network. The VKT indicator is used to determine the amount of traffic in a certain location over a given period of time.

Table 3: Percentage change in vehicle kilometres travelled in the inner city zone and for Stockholm County between 2005 and 2006.

	Inner city	County
Peak periods	-14%	-4%
Full 24 hours	-14%	-2%

Within the charge zone VKT has declined by approximately 14% between spring 2005 and spring 2006. This reduction applies both to an average weekday and for peak periods. For the whole of Stockholm County, the reduction is estimated to be just below 2% on an average weekday, and just below 4% for the morning peak period.

Journey times and traffic queues

As there has been a significant reduction in traffic in and out of the Stockholm inner city area between spring 2005 and spring 2006, the average queuing time has also fallen. Queuing time is defined as the difference between the actual journey time and the time during the journey that traffic flows freely. For road-users travelling in towards the inner city area on a normal weekday queuing time has fallen by approximately one third during the morning and by more than half during the afternoon/evening. At the same time, uncertainty about the time required for journeys has also reduced. As journey times have become more predictable, drivers can now plan their journeys without the need to include generous safety margins (as was necessary before) in order to ensure that they arrive on time.

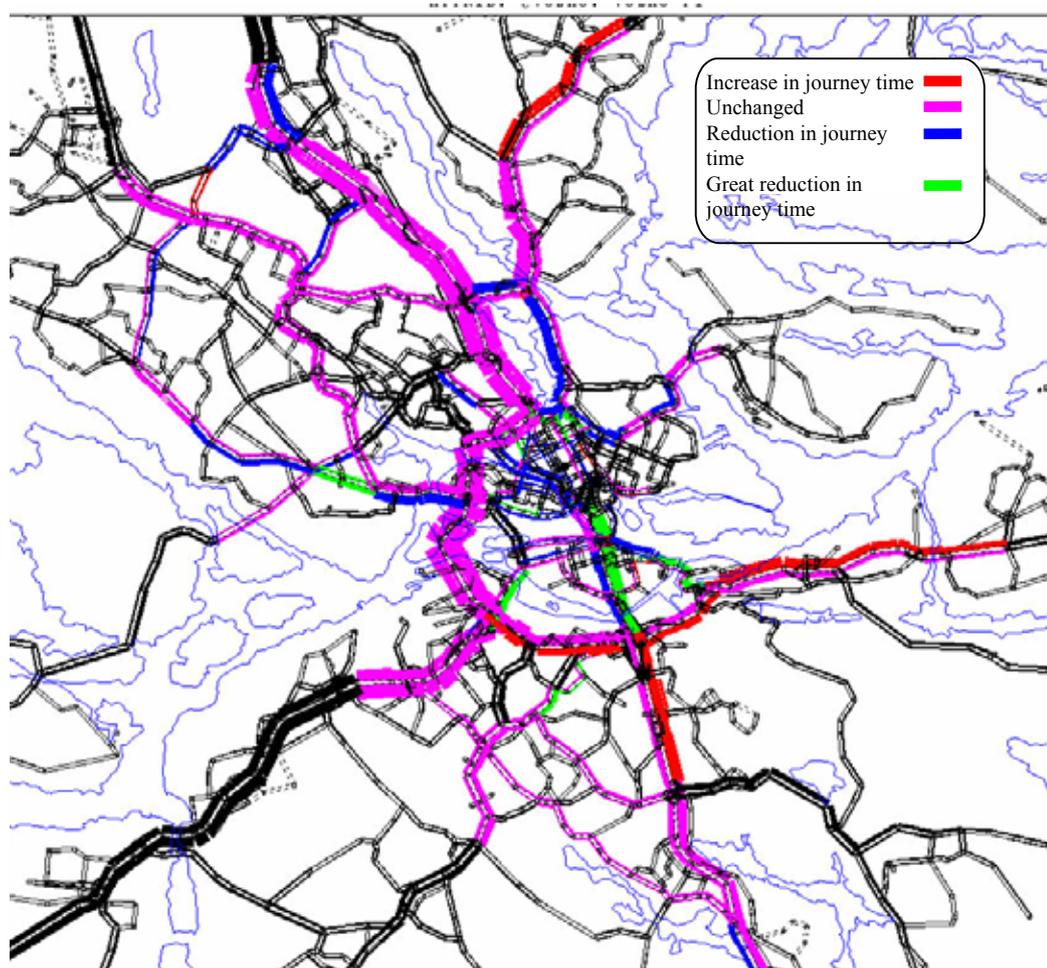


Figure 5: Difference in journey time along various monitoring routes, 2005–2006.

Figure 5 shows changes in journey times between spring 2005 and spring 2006 on the road network in Stockholm. As can be seen, the greatest reductions in journey times have been within the congestion-charge zone and on approach roads to the charge zone. On large segments of the road network outside the charge zone, journey times appear to be more or less unchanged. However, reduced journey times can be observed even on stretches of road far outside the charge zone, such as Bergshamraleden and Drottningholmsvägen. Journey times have increased first and foremost on Södra Länken and its extension eastwards in the direction of Nacka. Increases in journey times have also been reported on Nynäsvägen and sections of Roslagsvägen.

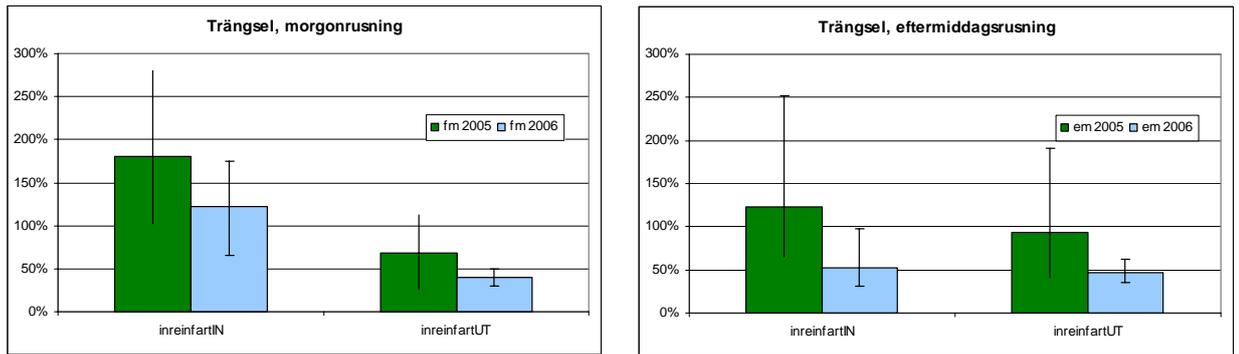


Figure 6: Percentage prolongation of journey time on inner approach roads – spring 2005 compared with spring 2006. Left figure: morning rush hour. Right figure: afternoon rush hour.

Figure 6 shows the prolongation of journey times. This is defined as the queuing time divided by the journey time when the traffic is flowing freely. The figure shows how much more time is required (i.e. the prolongation of journey time expressed as a percentage) to travel between two places in a comparison between the actual journey time and the journey time when the traffic is flowing freely. It would also appear that average journey times have been reduced. The upper and lower points on the black vertical lines through the respective columns of the bar chart show the levels of prolongation of journey times (as a percentage) for the 10% of the worst and best days respectively. The average prolongation of journey times during spring 2006 corresponds to the 10% of the best days in journey times during the spring of 2005.

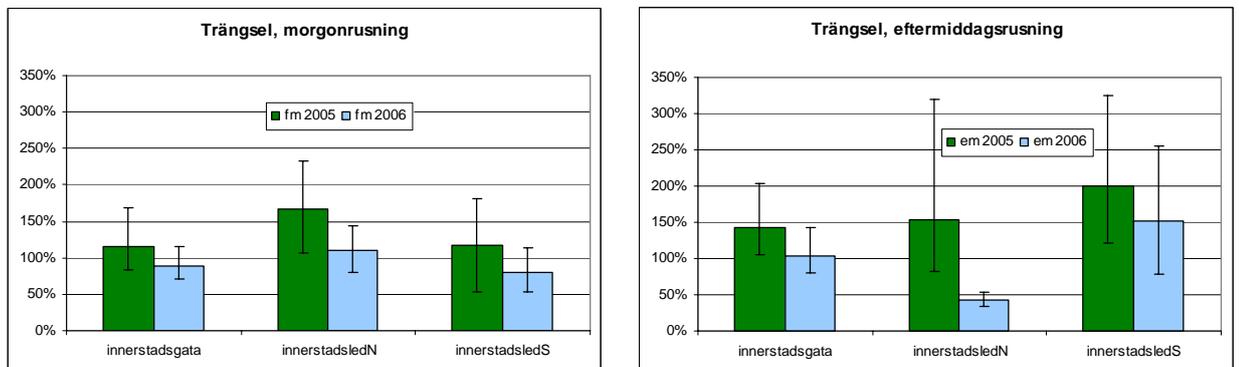


Figure 7: Percentage prolongation of journey time on streets and through-roads in the charge zone – spring 2005 compared with spring 2006. Left figure: morning rush hour. Right figure: afternoon rush hour.

In the mornings, congestion is usually most marked for vehicles travelling northwards along Essingeleden and those travelling west along Södra Länken. In the afternoons/evenings, congestion is most marked along these routes in the opposite directions. During the morning peak period average journey times have increased slightly in both directions on Essingeleden. However, this increase is not significant: in other words,

the normal day-to-day variation can be much greater than the differences in average journey times recorded between spring 2005 and spring 2006.

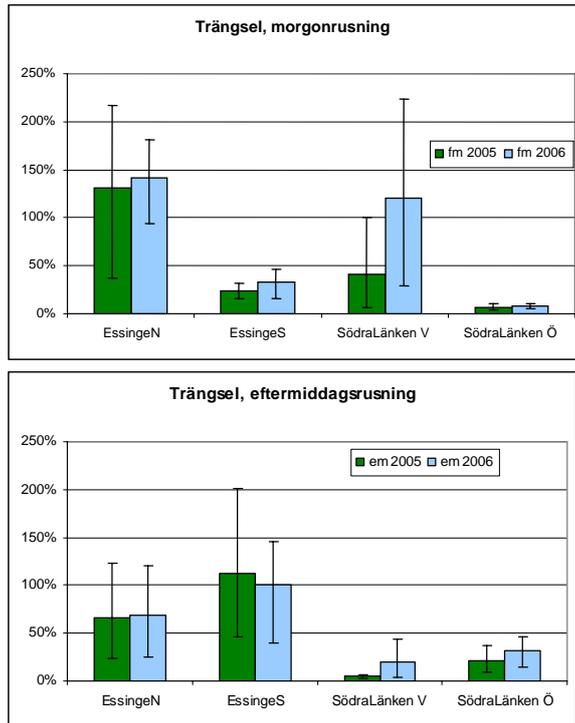


Figure 8: Percentage prolongation of journey time on the Essingeleden and Södra Länken bypasses – spring 2005 compared with spring 2006. First figure: morning rush hour. Second figure: afternoon rush hour.

On the other hand, there has been a steep increase in journey times for vehicles travelling west along Södra Länken (i.e. towards Essingeleden). At the same time, variations in journey times have also increased markedly, making this route very susceptible to disruptions. When the plans for Södra Länken were first conceived, it was anticipated that the bypass would be used by approximately 60,000 vehicles a day. Today, however, the route is used by approximately 100,000 vehicles on an average week-day.

Objective achieved for traffic reduction

Analyses of traffic measurements show that the objective to reduce by 10–15% the number of vehicles passing the congestion-charge zone during the morning and afternoon/evening peak periods has been achieved. The reduction is slightly greater than the target during the morning peak (approximately 16%) and significantly above target for the afternoon/evening peak period (approximately 24%).

The reduction in traffic (throughout the charge period as a whole) is more or less in the same in all directions, with the exception of traffic to and from Lidingö.

Changes in the traffic from year to year are affected by a variety of factors other than congestion charging. These include, for example, the opening of the Södra Länken bypass tunnel, changes in public transport and economic development. However, it is our opinion that such factors have had little impact on the reduction in traffic recorded between 2005 and 2006. Instead, this may be directly attributed to the success of the Stockholm Trial in achieving its objectives.

Objective achieved for improved flow of traffic

The objective to improve the flow of traffic on the busiest roads in Stockholm is a difficult one to quantify, particularly as “the busiest roads” have not been specifically defined. Prior to the commencement of the Stockholm Trial, the most congested roads were the inner approach roads to the charge zone, followed by through-routes within the inner city, Essingeleden (northbound) and the inner city streets. With the exception of Essingeleden, the flow of traffic has improved significantly on these roads. On Essingeleden itself there have been both deteriorations (most common) and improvements, but these variations have without exception been relatively small.

Normal seasonal and annual variation

To answer the question of whether it is meaningful to compare traffic figures from two different years, it is necessary to examine historical data to determine the degree to which traffic volumes generally fluctuate from year to year. Over the past 15 years the average absolute variation (i.e. the change, regardless of whether this is an increase or decrease) in vehicles passing in or out of what constitutes the charge zone during the trial with congestion tax has been less than 1%. The greatest change between two consecutive years (from 1997 to 1998) was just under 3%. This means that the reduction in traffic passing in or out of the charge zone recorded during the Stockholm Trial between 2005 and 2006 is very great compared to the normal variation from year to year.

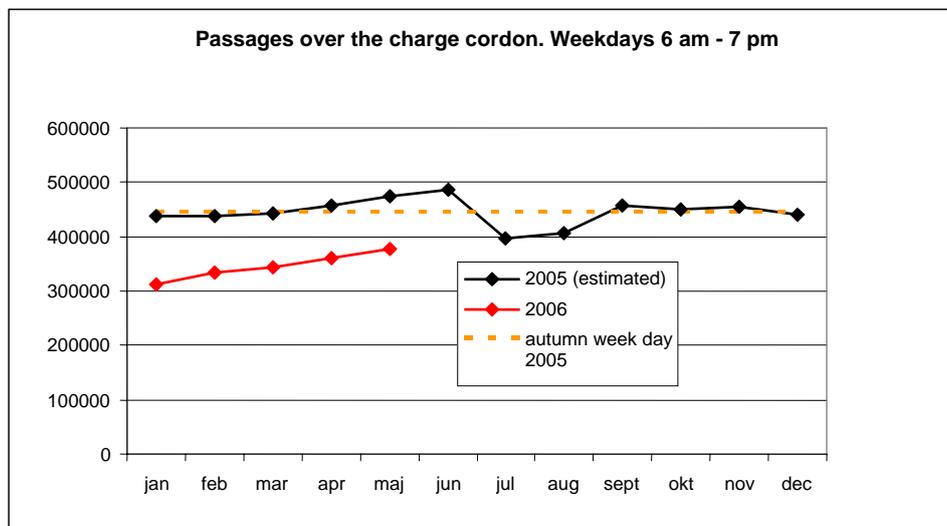


Figure 9: Number of vehicle passages over the charge cordon during weekdays 06.00–19.00.

Figure 9 shows a gradual increase in traffic during spring 2006, but this is mostly due to the fact that traffic always increases in the spring. The same pattern was observed in 2005. A month-for-month comparison between 2005 and 2006 shows that the effect of the congestion tax on the reduction in traffic has diminished by approximately 1 percentage point per month. The reduction in traffic passing the charge zone was 24% in February, 23% in March and 22% in April and May. It is probable that this slow, but clearly diminishing reduction in traffic shows the effect of an ongoing process of accustomisation. As the reduction in traffic is so similar from month to month, it seems likely that the level seen in the figures for April 2006 must be approaching a state of equilibrium in the traffic situation.

1.2 Road Traffic GPS

The purpose of this study is to measure and analyse the effect that the Stockholm Trial has had on journey times by improving the flow of traffic for ordinary commuters travelling by car.

The study includes data from 50 commuters, whose cars have been fitted with GPS-based equipment, which continuously measures and stores information about the vehicle's speed and location.

Questions to be answered by this study

This study, together with others, seeks to determine whether the trial has achieved its objective to improve the flow of traffic on the busiest roads in Stockholm.

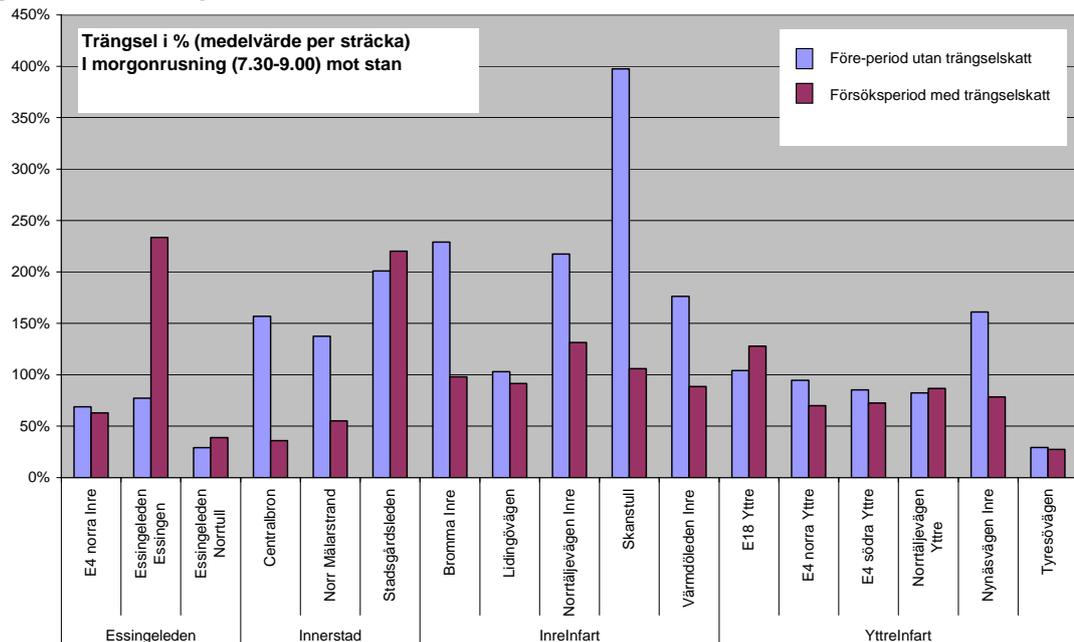
The study has also been designed to show changes in journey times and the flow of traffic during the trial period, compared with the period before the trial, and to cast light on how a number of commuters have chosen to adapt their travel habits.

Note, however, that this study can only provide answers to these questions for the routes monitored and the times that journeys along these monitored routes were made by the 50 commuters selected to take part in the study. To obtain a more complete analysis of the situation, this information must be complemented by a study of other road traffic measurements.

Method

All vehicle movements from the 50 commuters have been tracked and stored in a database, where monitoring routes have been defined to cover a representative selection of important approach roads and through-roads. Calculations have been made for *journey times* along these monitoring routes as well as for the *congestion coefficient*, which is defined as “the prolongation of journey time in percent, compared with the corresponding journey when traffic is flowing freely”. Accordingly, when a figure of 100% congestion is recorded, a journey will take twice as long as it does when traffic is flowing freely. Measurements from the period 1 October to 20 December 2005 are used as a pre-period reference value (i.e. prior to the introduction of congestion charging). These are then compared with measurements made during the period 20 January to 1 May 2006, (i.e. after the introduction of congestion charging). Public holidays, weekends and vacation periods have not been included in the measurements. This method has produced approximately 12 million measuring points, from which approximately 20,000 journey times have been tracked along 52 monitoring routes.

Examples of monitoring results – morning peak-period congestion on key routes



/Translation of figure/

Trängsel i % (medelvärde per sträcka) = *Congestion in % (average per route)*

I morgonrusning (7.30-9.00) mot stan = *Morning rush hour (7.30-9.00) into city*

Före-period utan trängselskatt = *Period before the trial with congestion charge*

Försöksperiod med trängselskatt = *Period during the trial with congestion charge*

Essingeleden = *Essingeleden bypass*

Innerstad = *Inner city*

Inre infart = *Inner approach road*

Yttre infart = *Outer approach road*

Conclusions

It is possible to arrive at the following conclusions for *the monitoring routes which have been taken by these volunteer drivers:*

Reduced journey times in the morning peak period on inner approach roads and through-roads in the inner city

Journey times during the morning peak period on *inner approach roads into the city* have been reduced significantly, on average by 33%. Congestion has also been reduced on roads in the inner city area, with the exception of Stadsgårdsleden. On the outer routes that have been studied, far beyond the congestion-charge zone, the reduction in congestion has been most marked in the early morning peak period (07.00–07.30).

Minor effects in the afternoon/evening peak period

With the exception of certain major through-roads in the inner city area, the measurements do not indicate any significant change in congestion for

traffic travelling out of the city during the afternoon/evening peak period. This result does, however, deviate from other measurements of journey times, which show clear reductions in congestion during the afternoon/evening peak period. However, it should also be borne in mind that congestion problems for traffic travelling away from the city centre are less severe to begin with.

Neither better nor worse on Essingeleden and from Lidingö

On the Essingeleden bypass *as a whole* no significant changes in congestion have been measured during the trial period. *Individual segments of this route* have, however, experienced increases and reductions in congestion respectively at various times during the day, and in both directions. Lidingövägen stands out as the only inner approach road where journey times have remained unchanged. The mean value for journey times to and from Lidingö through the congestion-charge zone is well under 30 minutes for all stretches, even if there are *individual journey times* in excess of 30 minutes for certain routes.

Has the Stockholm Trial achieved its objective to improve the flow of traffic?

Yes. The flow of traffic has improved on the busiest roads, with the exception of the central segments of Essingeleden. Congestion has eased considerably in those places where it was greatest before the start of the trial: namely, on inner approach roads to the city centre during the morning peak period. During the afternoon/evening peak period congestion has eased on through-roads within the inner city area, but this study has not been able to detect any major changes for traffic exiting Stockholm.

What effect has the trial had on ordinary commuters?

For the 50 volunteers in this study, congestion and journey times have been significantly reduced on the inner approach roads to Stockholm and routes within the city centre. However, as conditions on different stretches of road vary greatly, the gains in reduced journey times are much greater for some commuters than for others. Those for whom the benefits are least apparent are drivers using Essingeleden, Bergshamraleden, Stadsgårdsleden and routes in the direction of Ekerö. On these segments of the road network the improvements recorded in the flow of traffic are very small or non-existent.

The volunteers taking part in this study have, to some degree, reduced their use of Essingeleden in favour of other approach roads and roads through the inner city area. There has been a small increase in the number of commuters who travel extra early or extra late – in other words, during the charge-free time – but there has also been a small rise in the number who travel during the most expensive period in the morning peak traffic.

Other measurements must be studied for a more complete analysis

This study covers only the routes and times travelled by the 50 commuters who have volunteered to take part in the study. For that reason, other traffic measurements must be studied for a more complete analysis.

Please refer especially to “*Road Traffic – Analysis*” the report evaluating the effect of the Stockholm Trial on road traffic.

1.3 Traffic counts on approach routes

Manual traffic counts on the approach routes to Stockholm city centre have been carried out on three occasions. The approach routes coincide with control points for the congestion tax. The traffic counts were conducted to determine how the trial with the congestion tax has affected the relative numbers of different types of vehicle, such as private cars, goods vehicles and clean cars. In 2004, a census was taken of all cars and light goods vehicles, heavy goods vehicles, taxis, buses and motorcycles/mopeds on 16 approach roads. Similar traffic counts were repeated in 2006. In addition to this, a supplementary count was carried out both in 2005 and in 2006 on five approaches to count people as well as vehicles. The people passed the control points on foot, by cycle, or as passengers on underground trains, commuter trains or buses.

Table 1: Vehicles recorded by mode of transport on all 16 approach routes in to and out of central Stockholm during the congestion charging period (06.30–18.29)

Mode of transport in and out	Change	
	Number	%
Car	- 89,167	- 30 %
Light goods vehicle	- 10,136	- 22 %
Lorry	- 1,465	- 13 %
Motorcycle/moped	- 545	- 54 %
<i>Total</i>	<i>-101,313</i>	<i>- 28 %</i>

The result shows that the total traffic volume declined by 28% in 2006 compared with 2004 during the period when the congestion tax applied (06.30–18.29). Private cars accounted for the greatest reduction in absolute terms. Heavy goods traffic declined by slightly more than 10% during the congestion-charge period. The number of motorcycles and mopeds plummeted by more than 50% (probably due to the fact that there was a great deal of snow in the spring of 2006).

The proportion of clean vehicles travelling into and out of the Stockholm inner city area has more than doubled, from 0.8 percentage points in 2005 to 2.6 percentage points in 2006. Approximately 1.4% of the cars in Stockholm County are now clean vehicles. This means that clean vehicles are being used to a greater degree than ordinary vehicles for journeys into and out of the congestion charge zone.

In principle, there has been no change in the number of people travelling in the same car, which would suggest that the congestion tax has not had any effect on car-sharing.

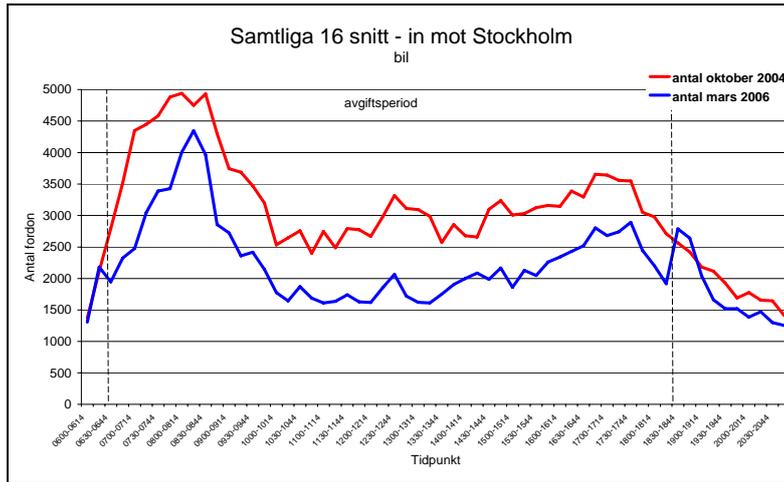


Figure 1: Number of private cars travelling into central Stockholm during the period 06.00–20.59

/Translation. Figure 1/

Samtliga 16 snitt – in mot Stockholm = All 16 sections – into Stockholm
 bil = car

avgiftsperiod = charging period

Antal fordon = Number of vehicles

Tidpunkt = Point of time

antal oktober 2004 = numbers in October 2004

antal mars 2006 = numbers in Mars 2006

One of the results of congestion charging has been that road-users have changed the timing of their journeys in order to minimise their outlay for the congestion tax. Figure 1 shows two new, small peaks in traffic immediately before and immediately after the charge period. This is because in 2006 certain drivers have chosen to travel into the central parts of the city earlier in the morning, while others have left the city later than they used to do compared with the figures for 2004.

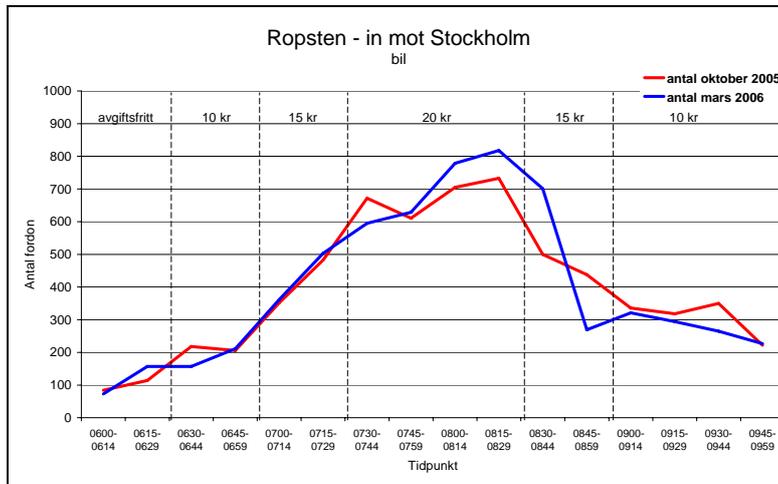


Figure 2: Number of private cars at Ropsten travelling into Stockholm during the period 06.00–09.59

/Translation. Figure 2/

Ropsten – in mot Stockholm = *Ropsten – approach road into Stockholm*
avgiftsfritt = *time free of charge*
Antal fordon = *Number of vehicles*
Tidpunkt = *Point of time*
antal oktober 2004 = *numbers in October 2005*
antal mars 2006 = *numbers in Mars 2006*

Comparisons between different approach roads show that there has been no reduction in traffic at Ropsten. This is an effect of the so-called “Lidingö Exemption”, which means that drivers who pass Ropsten are exempted from paying the congestion tax, provided that they pass through the charge zone within less than 30 minutes.

One example of how congestion charging has affected the choice of travel routes may be seen at Mariebergsbron Bridge. The number of light goods vehicles there has increased by 50%. This may be a result of the fact that these light goods vehicles choose routes via Marieberg in order to avoid the busy Essingeleden.

Another example of new choices of route is provided by statistics that show that the number of goods vehicles on Klarastrandsleden has halved between 2004 and 2006.

1.4 Queue measuring

For traffic planners it is natural to interpret the objective in terms of a reduction of 10–15% in the number of vehicles passing selected monitoring sites. A somewhat stricter interpretation of reducing “the number of vehicles on the busiest roads” is that the number of vehicles using the relevant segments of the road network during the mornings and afternoons must decline measured in terms of vehicle density (i.e. the number of vehicles per kilometre).

It seems fair to assume that, for members of the public inside the congestion-charge zone, the concept of “congestion” is perceived as the number of vehicles and the traffic queues that may be observed along a particular segment of road. Another reason for measuring the length of traffic queues is because it is assumed that this will provide a clearer indication of the congestion-reducing effects of the Stockholm Trial than changes in the flow of traffic and journey times can do.

In December 2005 the Royal Institute of Technology in Stockholm (KTH) was commissioned to measure the length of a limited number of traffic queues on specific routes in order to provide data for the monthly indicators for the Stockholm Trial. The purpose was to measure the effect of the Stockholm Trial on the total traffic queue length on selected routes and at selected peak periods. The queue length measurements were limited to the following segments of the road network:

- Routes outside the congestion-charge zone:
 - E4 – Essingeleden Bypass between Bredäng and Fredhäll
 - E18 – Roslagsvägen between Danderyd Church and Roslagstull
- Routes within the zone: Klara Strandsleden between Solnabron Bridge and Tegelbacken
- Major streets within the zone: Sveavägen

Measurements were made with the aid of a specially equipped vehicle, which travelled back and forth along the route, registering any traffic queues and the length of these in each direction. The total length of all the queues along each monitoring route was calculated and recorded as “*queue length*”. The *median value of the queue length* was then computed on the basis of all the measurements made when driving the route during the monitoring period, as was the *maximum queue length* recorded for all monitoring periods. The measurements were made on a Tuesday or Wednesday in the middle of each month during the period January to April 2006. On routes outside the charge zone, these measurements were made during the morning peak period (07.00–10.00); on routes and streets inside the charge zone they were made during the afternoon (15.00–18.00).

As anticipated, the queue length measurements showed dramatic variations. Taken together with the small number of observations (6–14) made on each route during the chosen monitoring periods (07.00–10.00 and 15.00–18.00), this means that the results obtained were in many cases not statistically significant.

The observations made on the basis of queue length measuring may be summarised as follows.

E4 – Essingeleden between Bredäng and Fredhäll during the morning peak period:

Northbound traffic

The result for January 2006 after the start of the Stockholm Trial indicated that queue lengths had fallen compared with April 2005. During the following months, however, queue lengths increased, peaking at a level in March 2006 that was significantly higher than in April 2005. It would appear likely, however, that this result was affected by a specific incident, even if no significant incident was reported on the route segment concerned on the day when the measurement took place. The median queue length recorded for April 2006 was approximately twice as long as in April 2005, but because of the large variations between different queue length measurements on the segment of road concerned, the result was not significant.

Southbound traffic

During the periods April 2005 and January–April 2006 there were no queues or only insignificant queuing.

E18 – Roslagsvägen between Danderyd Church and Roslagstull during the morning peak period.

Southbound traffic

During the first months of this year queues were shorter than in April 2005, but subsequently they increased significantly. In April 2006 the queue length had returned to the same level (significant) as before the Stockholm Trial (April 2005).

Northbound traffic

During the periods April 2005 and January–April 2006 there were no queues or only insignificant queuing.

Klarastrandsleden between Tegelbacken and Solnabron Roslagstull during the afternoon/evening peak period

Northbound and southbound traffic

Compared to conditions before the Stockholm Trial traffic queues disappeared more or less completely (significant).

Sveavägen between Sergels torg and Sveaplan during the afternoon/evening peak period

Northbound traffic

Queues were created primarily at intersections controlled by traffic signals and were never extensive in nature. However, they increased significantly (40%) from April 2005 to April 2006, despite the fact that the average speed recorded for the monitored segment of road was somewhat higher on the last occasion that monitoring was undertaken (18 kph compared to 16 kph: not significant).

Southbound traffic

As was the case with the northbound traffic, queues were created by traffic signals, but were never extensive in nature. During the Stockholm

Trial (April 2006) the median queue length had, however, expanded to approximately twice the length recorded in April 2005 (significant). In spite of this, there was no change in the average speed on the monitored segment of road (approximately 13 kph).

2. Public transport

Introduction

Objective

For many years Stockholm Transport (SL) has regularly followed up passengers' experience of service quality, changes in travel demand, and delivered traffic services. The follow-ups have been intensified and the findings speeded up during the Stockholm Trial, when passengers in the county of Stockholm have had access to more travel possibilities than ever. There are other reasons as well for evaluating the effects of public transport. The overall objective is to evaluate how well SL succeeds in meeting the increased demand for public transport and achieving its quality goals. In the short run this is a question of being able to quickly adjust traffic services to meet demand and following up changes in conditions for traffic production, such as road accessibility for buses. A more long-term objective is to balance the outcome with the previous prognoses of changes in demand, in order to make adjustments in the planning tools. Measurements of SL's driving times and boarding and alighting passengers, etc. are made automatically, with the exception of underground traffic, where passengers are counted manually. Passengers' experienced quality is surveyed through telephone interviews and questionnaires on-board the various vehicles.

Hypothesis

In 2003, in connection with the positive stand of Stockholm County towards a congestion charge/tax trial, SL made a series of traffic analyses to assess its expected effects on SL services. The analyses indicated an increased demand of about 12,000 passengers, equivalent to 7-8% of trips on public transport in the direction towards the inner city during the peak traffic period from 6.00 to 9.00 in the morning. Throughout the county, travel on public transport was estimated to rise by 3-4% during this morning period. The comparative year was 2002. In addition SL forecasted an accentuated travel peak in peak hour traffic when the time-differentiated charge/tax would be at its highest. Reduced car traffic in the inner city was assumed to carry with it improved accessibility for the inner city bus routes and for bus traffic on approach roads. An important goal for SL has been for prospective passengers to be met by a quality in SL service at a level of at least the situation before the trial, and for established passengers not to be affected by increased crowding or other unfavourable changes because of the Stockholm Trial.

The Stockholm Trial is not the only reason for an increase in demand for public transport. Several other external factors also have an impact, such as the price of petrol and the general economic situation of the society.

Extended public transport

Starting on 22 August 2005 SL's extended service began to operate on roads and tracks. The largest public transport investments in Stockholm in modern time had thus commenced as planned. SL's entire range of services was extended by 7%. Overnight, residents of the county were of-

ferred considerably more travel alternatives for journeys to and from the inner city. The point of time coincided with a new winter timetable and the implementation of normally large changes in services. The extended service was marketed intensively both locally within the county and in the daily press (example in Appendix 3 in the actual report). The media gave SL's new traffic services extensive coverage as well. The investments consisted partly of extended public transport and partly of 1,500 additional spaces in park-and-ride facilities, in both new and existing locations. Rail service was reinforced by a slight increase in new departures during the morning and afternoon peak periods and by service with longer trains during periods outside the peak hours. Bus service was increased by 14 new direct buses with enhanced comfort from Stockholm's outlying municipalities to the inner city, two new trunk bus routes to the inner city and more frequent trips on existing direct bus routes and trunk buses in the inner city. For this increase 197 new buses and 15 new and enlarged depots were required. Several measures for improved accessibility for bus services to/from and within the inner city were also taken.

Performance of public transport during the trial

Bus and suburban rail services have functioned well throughout during the trial period and many passengers have travelled with buses on the new routes. Beginning in mid-August the oldest of the commuter train carriages were successively replaced with SL's new modern commuter trains. In late autumn there were difficult disturbances in underground and commuter train traffic due to slipperiness from fallen leaves and technical problems with one of the underground's older carriage types. A relatively large number of departures had to be cancelled. The cold and snowy winter continued to cause problems for the oldest commuter train carriages and for the track and switches in the National Rail Administration's infrastructure, which led to poorer punctuality in the beginning of 2006. Traffic in the underground was also affected by the difficult weather conditions.

Results

Adaptation of public transport to changes in demand

From the start of the extended public transport in August 2005, very satisfied passengers steadily found their way to the new direct bus routes. When the congestion tax was introduced on 3 January there was a marked increase, as expected, in the demand for public transport. The prognoses used to dimension SL's extended service proved to be relatively correct. Corrections in offered services were made by degrees, based among other things on ongoing evaluations. More commuter train departures were added around the turn of the new year. A number of supplementary buses were made available for use by special personnel if reinforcement of the direct bus routes was deemed necessary. Indications of increased crowding on the underground led to four new relief buses being put in operation from the closest suburbs in early January, while an increased demand for commuter train services in February resulted in two new direct bus routes from Salem and Upplands Väsby to the inner city. The carriage situation in the underground gradually improved and in early March two of the four underground-reinforcing bus routes were discontinued.

Changes in travel

Total boarding and boarding in the inner city

During spring 2006 there was an increase of 6% in travel on all of SL's services, with 140,000 more boarding passengers (partial journeys) per weekday compared with the year before. This is the equivalent of an average of 40,000 more passengers, which means 80,000 more journeys on SL during an ordinary weekday. Every weekday in spring 2006, SL handled an average of 680,000 passengers making 1,480,000 journeys.

On the inner city bus routes there was an increase in travel during spring 2006 of 25,000 more boarding passengers per day, an equivalent of 9% compared with spring 2005. Of these 25,000, 15,000 more boarded the inner city local routes (+ 14%) and 10,000 more boarded the inner city trunk bus routes (+ 6%) every day.

During autumn 2005, when SL's expanded services were in operation but motorists were not yet being charged a congestion tax, the increase in travel on SL was about 2% compared with autumn 2004.

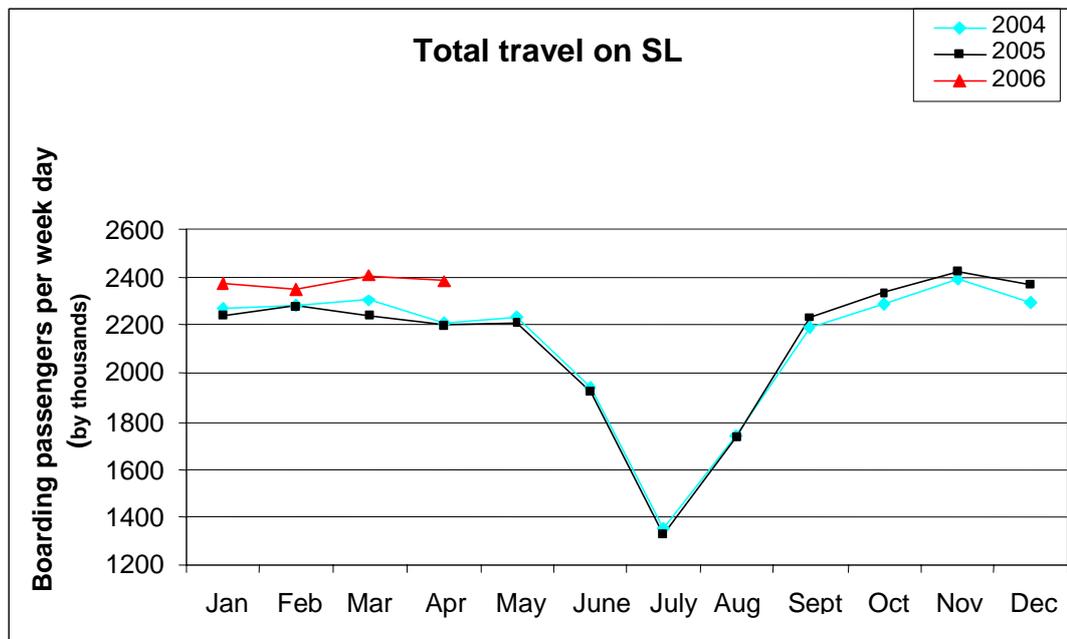


Figure 1. Travel on public transport by month for years 2004, 2005 and 2006.

Travel on the new direct bus routes during autumn 2005 was on a level of between 10,000 and 11,000 boarding passengers per day and increased to about 13,000 boarding passengers during spring 2006.

Travel on approach roads to and from the inner city

In spring 2006, 45,000 more passages by public transport were made on the approach roads to and from the inner city during one weekday, as compared with the corresponding period in 2005. This is the equivalent of over 20,000 more passengers taking public transport to the inner city, an increase of 6%. Underground transport increased the most in absolute

numbers, 25,000 more passages per whole weekday, followed by bus transport, which increased by 16,000 more passages.

During the maximum traffic period in the morning between 7.30 and 8.30 the increase in spring 2006 compared with spring 2005 was just under 8,500 more passages, equivalent to 8%, of which more than 7,500 were made in the direction towards the city, corresponding to an increase of 10%. Under these conditions – the peak hour in the morning and the peak direction towards the city – it was travel on the underground that increased the most in absolute numbers. Underground transport during that period increased by just under 5,500 passages (+ 13%); bus transport by almost 3,000 passages (+ 28%). Travel on commuter trains decreased however by almost 1,000 passages (- 6%), while suburban rail transit increased by under 500 passages (+ 5%) in the direction towards the city.

The figure below shows that it is inward travel by underground over the Solna approach (blue line) and from the south over Skanstull (green line) and Liljeholm Bridge (red line) that increased the most during the peak traffic hour. On the other hand there has been a slight decline in travel on the green line underground from the west via Traneberg Bridge. Travel by bus has increased primarily from the north via the Solna approaches and Stocksundet sound and from the south via Skanstull. Changes in travel by commuter train are non-existent/barely noticeable (Solna approach and Årsta Bridge).

Inresande 07:30-08:30 uppdelat på innerstadssnitt och trafikslag

Differens mellan våren 2006 och våren 2005

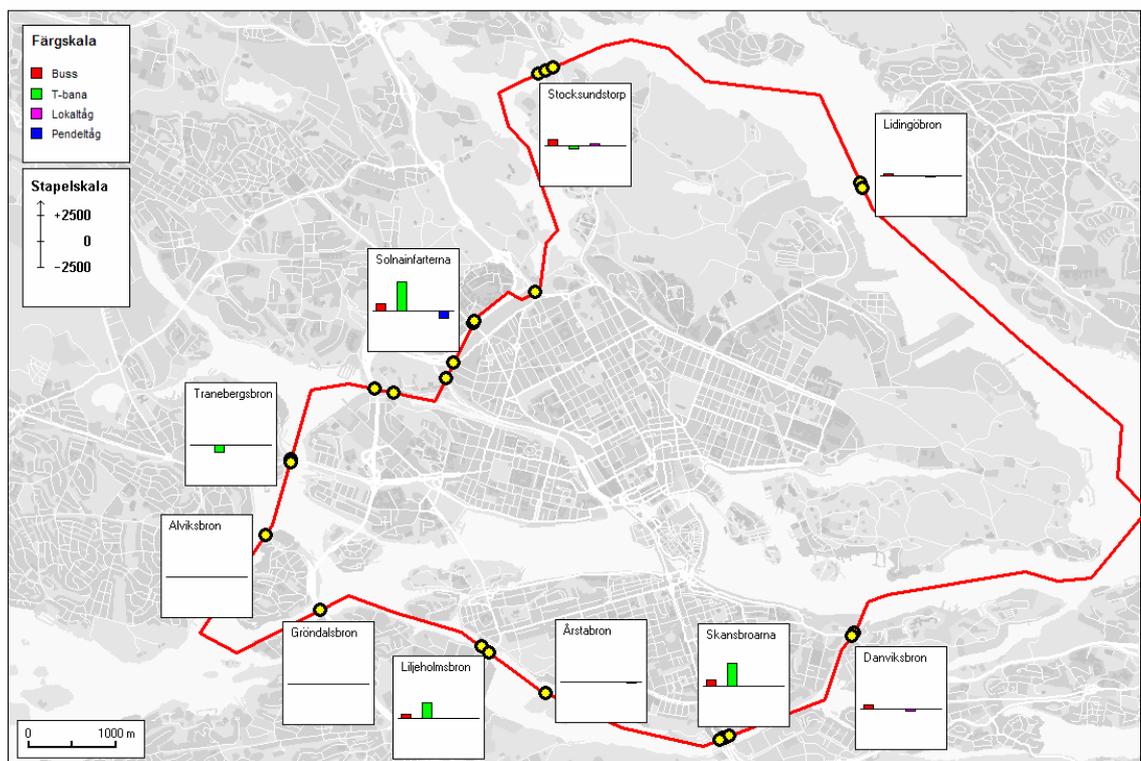


Figure 2. Changes in travel via approaches to the inner city 7.30-8.30 a.m., spring 2006 compared with spring 2005.

/Translation. Figure 2/

Inresande 07:30-08:30 uppdelat på innerstadssnitt och trafikslag = *Inward travel 7.30-8.30 divided into inner-city segment and mode of transport*

Differens mellan våren 2006 och våren 2005 = *Difference between spring 2006 and spring 2005*

Färgskala = *Colour code*

Buss = *Bus*

T-bana = *Underground*

Lokaltåg = *Local train*

Pendeltåg = *Commuter train*

Stapelskala = *Bar scale*

Stocksundstorp = *Stocksund sound*

Lidingöbron = *Lidingö Bridge*

Danviksbron = *Danviks Bridge*

Skansbroarna = *Skans bridges*

Årstabron = *Årsta Bridge*

Liljeholmsbron = *Liljeholm Bridge*

Gröndalsbron = *Gröndal Bridge*

Alviksbron = *Alvik Bridge*

Tranebergsbron = *Traneberg Bridge*

Solnainfarterna = *Solna approach roads*

During autumn 2005 the increase in travel on the approach roads to the inner city was an average of 2%, corresponding to 16,000 more passages per day compared with autumn 2004.

Sold travel cards

Sales of SL travel cards (yearly ticket, season ticket and 30-day card) increased by close to 7% during the period from January-April 2006 compared with the same period in 2005. An income analysis is to be made.

Accessibility for bus traffic on approach roads and in the inner city

Accessibility on approach roads

Accessibility for the new bus routes to and from the inner city is relatively good, with one exception, which is the street *Sveavägen*, where the average speed is only 12-14 km/hr. Compared with autumn 2005 a general improvement has taken place on all approach roads, especially during the maximum traffic period of 7.30-8.30 a.m.. The average speed has increased by 1-4 km on all approach roads with the exception of Norra Sköndal-Vattugatan, where the average speed has increased by as much as 12 km/hr during the peak-traffic hour.

Accessibility in the city centre

Bus traffic in the inner city has achieved somewhat improved accessibility in spring 2006 as compared with spring 2005. The figure below shows that the average speed throughout most of the trunk route network during the peak morning hour from 7.30-8.30 is unchanged or has improved/deteriorated by a maximum of one km/hour. The only exceptions are the sections Karolinska Hospital-St Eriksplan (an effect of the new

bus lane on Torsgatan Street), Södersjukhuset Hospital–Skanstull, and Sofia–Renstiernas gata, where the improvements are somewhat better. At Slussen, problems with bearing capacity have led to a redirecting of bus services to a more intricate route, which has led to longer driving times and thus longer travel time for a very large number of passengers.

Medelhastighet på innerstadens stomlinjer 07:30-08:30

Differens mellan våren 2006 och våren 2005

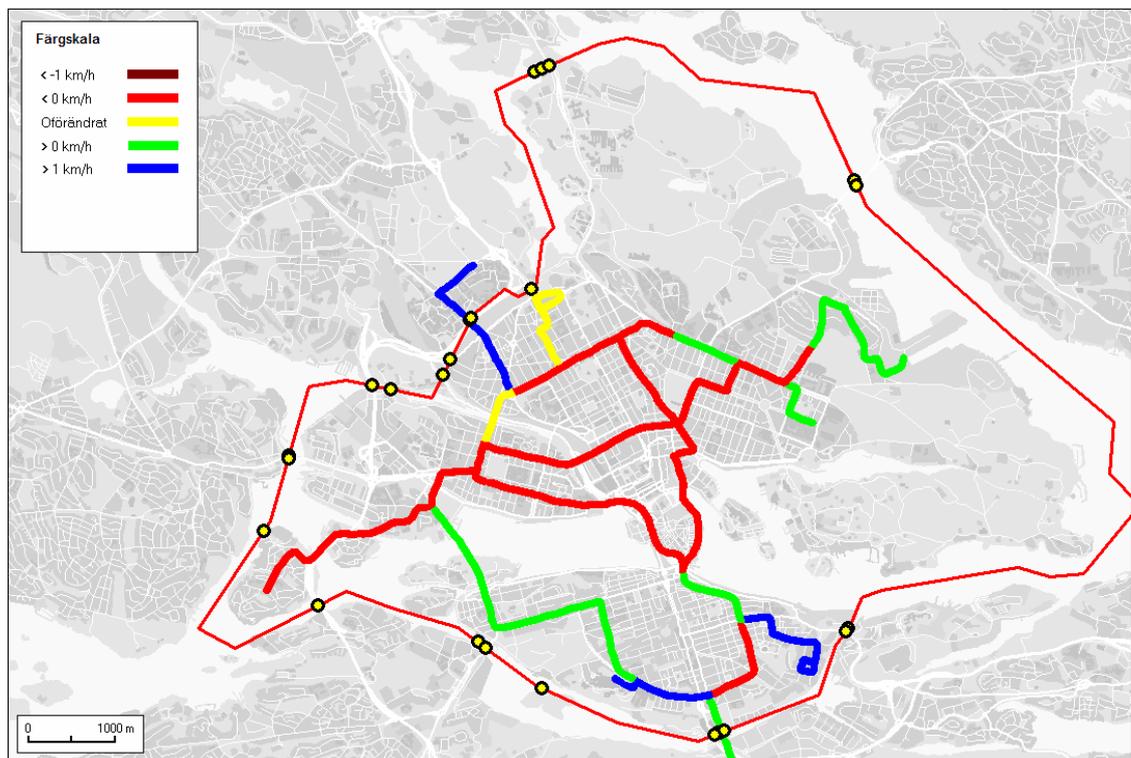


Figure 3. Changes in average speed on trunk route network 7.30-8.30 a.m., spring 2006 compared with spring 2005.

/Translation. Figur 3/

Medelhastighet på innerstadens stomlinjer 07:30-08:30 = Average speed on inner city trunk routes 7.30-8.30 a.m.

Differens mellan våren 2006 och våren 2005 = Difference between spring 2006 and spring 2005

Färgskala = Colour code

Oförändrat = Unchanged

One reason why the measured improvements have not been greater is an effect of the fact that bus services follow and are adapted to a stipulated timetable. This has also meant that punctuality has not been affected, totally speaking, according to measurements of agreed-upon punctuality for the inner city bus services. On the other hand the measurements show that punctuality for the inner city's trunk routes on arrival at the terminus have improved appreciably.

An interview survey carried out in April with 190 bus drivers who drive more or less daily in the inner city provides further indication that accessibility in the inner city has improved. A figure of 80% of the drivers felt that it was easier to get through traffic and keep to the timetable, and 60% felt they experienced less stress.

Delivered quality of SL services

Punctuality – approved departures

During spring 2006 punctuality (percentage of approved departures) in underground traffic was 90%, a decrease by 5 percentage points compared with spring 2005. Commuter train punctuality was 80%, also a decrease of 5 percentage points. Punctuality for buses and suburban rail transit remained high, 97 and 94% respectively. Bus services in the inner city were an unchanged 86%.

During autumn 2005, when the Stockholm Trial so far only consisted of extended public transport, punctuality in underground traffic was 93%, which was somewhat lower than autumn 2004 due to problems on the green line. Commuter train services in autumn 2005 also had a punctuality of 80%, which was 6 percentage points worse than autumn 2004.

Conducted services

During spring 2006 a greater share of both underground and commuter train departures was cancelled than in spring 2005. The proportion of conducted services (conducted per booked departures) for the underground was 97.5%, a decrease of 2 percentage points, while the figure for commuter trains was 95.8%, a decrease of 3 percentage points. It was above all in the month of January that there were problems in commuter services and in February-April on the red line on the underground. On the other hand the proportion of conducted services in spring 2006 has remained on a very high level for bus and suburban rail services, 99.7% and 99.3% respectively. The outcome for bus services in the inner city was even better, with 99.8% of the promised departures being driven, a slight improvement compared with the spring before.

During autumn 2005 the proportion of conducted commuter train services was on the same level as autumn 2004, approximately 97.5%. The red and blue lines on the underground, like autumn before, had few cancelled trips. On the green line a relatively large number of trips had to be cancelled in November and December (up to 13%), which was also the case in autumn 2004.

Used standing room capacity

Used standing room capacity (number of standing passengers per number of standing room places) during passage on approach roads is a relative measure of capacity utilisation and thereby also a measure of the momentary crowding situation onboard various types of public transport. The total share of standing passengers has increased somewhat seen over a 24-hr period. During the peak hour from 7.30-8.30 in the morning in the direction towards the city the increase is even higher, especially on the un-

derground. On buses going in the direction towards the city centre the crowding situation is unchanged and on the commuter trains there has been a certain improvement compared with spring 2005.

Proportion of standing passengers

The proportion of standing passengers (standing km per person km) is a measure that not only describes the momentary crowding situation on approach roads to the inner city but also the length of the distance during which passengers stand. During spring 2006 the proportion of standing passengers on SL services totalled an unchanged 5% compared with spring 2005. The underground had an increase of 2 percentage points, rising to 9%, while suburban rail services also rose by 2 percentage points, to 4%. Inner city bus services increased by 1 percentage point to 8% and the proportion of standing passengers on commuter trains had decreased by one percentage point, to 2%.

Passengers' experienced quality

The proportion of SL passengers who are satisfied with SL services has decreased from 66% in spring 2005 to 61% in spring 2006. The decrease applies to all modes of transport but passengers are much less satisfied with primarily commuter services. This is due to all the delays and cancelled trips that took place in commuter train services. The fact that more passengers experience increased crowding on public transport has also influenced their total assessment. On the new bus routes the situation is different, with 87% satisfied in spring 2006.

Experienced keeping on time

Totally speaking SL's ability to keep on time was experienced in 2006 as poorer compared with spring 2005. The experienced deterioration applies to all modes of transport but is especially pronounced for commuter trains. The proportion of passengers who are satisfied with SL's ability to keep on time has declined from 66 to 64%. On the new bus routes 76% were satisfied with the ability to stay on time.

Experienced crowding

Half of the SL passengers were not inconvenienced by crowding in vehicles in spring 2006, which is a decline by 3 percentage points compared with spring 2005. Comparing modes of transport it is commuter passengers who were most inconvenienced by crowding. Delays and cancelled trips implied crowding on the trips that were not cancelled. An exception is passengers on the Södertälje commuter line, where the proportion who were not bothered by crowding increased by 3 percentage points. On the new bus routes 73% of the passengers said they were not bothered by crowding, which is 12 percentage points better than for bus services at large.

Changed travel pattern

Passengers on the new bus routes

Passengers on the new bus routes, including the trunk routes from Nacka and Värmdö, were asked both in autumn 2005 and in spring 2006 how they had taken a similar journey earlier. The study in autumn 2005 showed that 84% of the passengers on the new routes said they had taken a similar journey with SL before, meaning they had changed to the new bus routes from another mode of travel with SL. An average of 6% of the passengers had previously driven a car the whole way, while 10% had previously not taken a similar journey. When the study was made in spring 2006 the outcome was different. Only 1% said they have previously made a similar journey by car and as many as 24% that they had not previously made a similar journey. A figure of 67% had travelled with SL before and 7% had made a journey combining car and public transport.

The main reason that passengers who had previously driven a car chose to switch to the new bus routes was that they experienced them as convenient (50%). Other reasons were that they experienced the new routes as faster (30%), easier because you don't have to make a change or fewer changes (26%) and finally the congestion tax (14%).

Passengers on the new bus routes travel frequently on public transport. Most of them travel daily or almost daily with SL.

County residents

In the continuous interviews conducted by SL with county residents to measure attitudes to public transport a question has been included regarding the extent to which they have changed their travel with SL due to the congestion tax. During the entire year of 2005 roughly 13% of the county residents thought they would travel with SL to a greater extent and 5% to a lesser extent. In spring 2006 the figure was 5-6% for those who said they had actually travelled with SL to a greater extent and about 4% who said they had travelled with SL to a lesser extent.

Conclusions

The following conclusions can be drawn from the evaluation made so far of the Stockholm Trial's effect on SL services and passengers. It should be noted that the changes are not solely the result of the Stockholm Trial but also of higher petrol prices and the general economic development of the society.

Results in brief

- Travel with SL rose in autumn by about 2% compared with the year before and has increased during spring 2006 by about 40,000 more passengers, corresponding to 6% compared with spring 2005.
- Travel on approach roads to Stockholm's city centre during spring 2006 has risen by 20,000 more passengers, which is also an increase of 6% compared with spring 2005. Passengers on the underground stood for over half of this increase.
- Travel in the direction towards the city during the peak period has increased to an even higher degree. During the peak traffic hour from 7.30-8.30 a.m. the increase in the direction towards the city is 10%. The number of passengers on the underground rose during that hour by 13%.
- Bus services on approach roads towards the inner city have achieved improved accessibility.
- There are many indications that accessibility for buses in the inner city is also improved.
- Carriage shortage and technical problems in commuter and underground services have caused a decline in passenger satisfaction with SL services in spring 2006 compared with the spring before. Buses and suburban rail services during the trial period have run smoothly, with few delays and cancelled trips.

Conclusions

- SL's preparedness for handling new passengers has been good. The comprehensive 7% expansion throughout SL services was carried out overnight and ran smoothly from the first day in August 2005.
- Regarding the travel increase in the direction towards the inner city the outcome is well in keeping with the prognosis. On the other hand the total increase in number of passengers on SL has surpassed the prognosis. This may be due to the fact that factors in the external world, such as petrol prices and economic development, have had a relatively large impact on travel by public transport.
- During the maximum traffic period from 7.30-8.30 a.m. there was a higher rise in travel in the direction towards the city than the total over a 24-hr period, which had also been predicted.
- The goal of maintaining quality for existing and new passengers on SL services has not been achieved, as there has been a decline in the proportion of satisfied passengers, particularly due to decreased satisfaction with the crowding situation and with keeping to the timetable. This is the result of the above-mentioned problems in operating the commuter and underground trains, but probably also of the substantial increase in passengers on the underground.

- Accessibility for bus services to, from and within the inner city was expected to increase and indeed has occurred, above all accessibility for bus traffic on the approach roads.
- SL's introduction of direct bus routes from the outlying municipalities to the city centre has had a favourable outcome. A substantial number of passengers on the new direct buses are satisfied with the service. Most of them travel daily or almost daily with SL.

Methods and monitoring data

Travel and traffic monitoring

SL's travel and traffic measurements are made automatically for most modes of transport by means of ATR, automatic traffic recorder devices. The exceptions are the underground and the Saltsjöbanan rail line, which are measured using MTR, manual recording.

Using ATR about 10% of all traffic involving buses, suburban rail trains and commuter trains is counted every day. The monitoring data is compiled based on ordinary weekdays, Monday-Friday. Monitoring data for spring 2005 and spring 2006 involve the monitoring period 13 February-13 April, except in regard to information about the number of boarding passengers, where the monitoring period is January-April. Based on this monitoring data the number of boarding passengers, driving and stop times and number of passengers onboard during passage on approach roads into Stockholm city centre are counted.

During manual traffic recording in the underground, observations are made of the number of passengers on the trains at so called branching points, namely Gullmarsplan, Alvik, Liljeholmen, Östermalmstorg and Västra Skogen. The observations are made on ordinary weekdays, Monday-Thursday, between 6.00 a.m. and midnight. Traffic is observed going both north and south for each branching point during an equivalent of two weekdays per month. Based on this monitoring data, a model-based calculation is made of the total number of boarding passengers and average used seating capacity per red, green and blue line for one 24-hr period. Boarding and departing passengers at Slussen on the Saltsjöbanan line have also been counted once a day every month beginning in 2006.

Passengers' experienced quality and changed travel pattern

To measure passengers' experience of the quality of SL services, two monitorings are made annually, one in spring and one in autumn. The survey takes place in the form of questionnaires distributed to passengers in the vehicles. For every monitoring occasion some 18,000 interviews are carried out, at least 500 in each contract area. In autumn 2005 and spring 2006 the study was extended to include at least 200 interviews per route on the new direct buses. The monitorings in spring were carried out between two school holidays in February and April. Simultaneously with the quality surveys on the new bus routes, travel matrix studies in which passengers were asked how they used to take the same trip were conducted in autumn 2005 and spring 2006.

3. Pedestrian and cycle traffic

The Stockholm Trial's impact on pedestrian and cycle traffic has been studied to see if, and in which case how, the number of pedestrian and cycle trips has been affected (Trivector, 2006:50). Some of the tested hypotheses were:

- Short car trips across the charge zone will be replaced by pedestrian and cycle traffic
- Increased public transport travel will lead to more and longer feeder connections by foot and cycle
- An improved street environment will generate a better atmosphere and greater safety, inducing more people to want to walk and cycle.

Effects on pedestrian and cycle traffic

As the basis for the analysis of pedestrian and cycle trips the following were available:

- Traffic measurements at five approaches before and during the Stockholm Trial, including walking and cycling (October 2005 and March 2006, respectively).
- City of Stockholm's cycle counts (May/June annually since 2001) (see Figure 1).
- Travel pattern studies in Stockholm County before and during the Stockholm Trial (September/October 2004 and March 2006, respectively)
- Interviews with cyclists at four places in Stockholm's inner city, before and during the Stockholm Trial (August/September 2003 and April/May 2006, respectively)

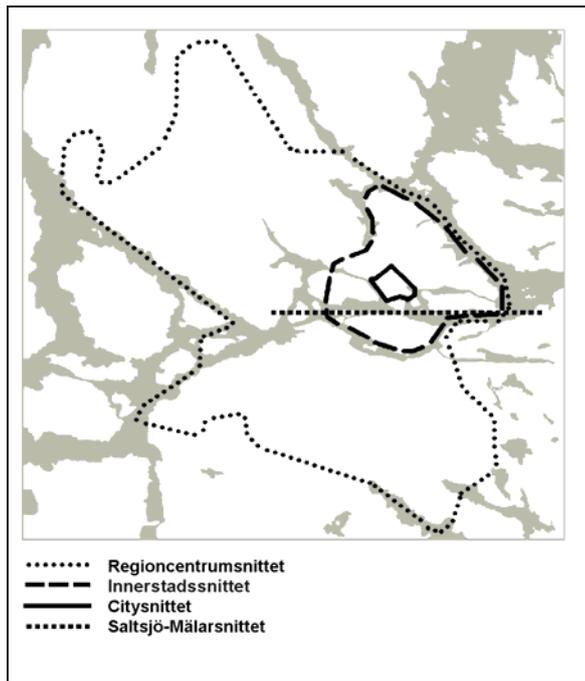


Figure 1. Zones where cyclists were counted.

/Translation. Figur 1/

Regioncentrumsnittet = *Regional centre zone*

Innerstadssnittet = *Inner city zone*

Citysnittet = *City zone*

Saltsjö-Mälarsnittet = *Saltsjö-Mälaren zone*

It is not possible from the traffic counts at the five approaches to determine whether or not there were increases in pedestrian and cycle traffic, since at the time for the 2006 traffic count winter road conditions still prevailed. For the same reason it is not possible to use the travel pattern study to say anything about whether pedestrian and cycle traffic has been affected by the Stockholm Trial.

On the other hand the cycle counts carried out by the City of Stockholm in May-June 2001-2006 show an increase in cycle traffic in all zones: in the inner city zone, city zone, Saltsjö-Mälaren zone and on central streets (see Figure 1). The increase in 2006 compared with the maximum value for the previous five-year period is between 0 and 16%, depending on which zone is involved. The increase in 2006 compared with the mean value for the previous five-year period is between 10 and 32%, depending on which zone is involved. The number of cyclists through the inner city zone has increased at all counted points except on the Gamla Lidingöbron bridge and on the street Roslagsvägen. Streets in the city zone where there was the greatest increase in the number of cyclists in 2006 compared with 2004 and previous years are Sveavägen, Vasagatan and Kungsbron, among others. On these streets the number of cyclists in 2006 was up to 13% higher than the maximum value for the previous five-year period. In the Saltsjö-Mälaren zone there were more cyclists on both the Västerbron bridge and in the Slussen traffic area.

It is not possible to say with certainty that the increase in the number of cyclists is an effect of the environmental charges/congestion taxes as seasonal variations, cycle path expansions and exceptionally good weather may have influenced the values, but a certain part of the effect should be ascribable the Stockholm Trial.

The findings from the interviews with cyclists also indicate a certain experience of improvement in the traffic situation, which in turn may explain the increase in the number of cycle trips. The interviews show that:

- A majority of cyclists at the four studied places said they cycle as much now (meaning spring 2006) as last spring.
- Just under one in ten said they cycle more after the introduction of the environmental charges/congestion taxes. The increase in cycling is in good agreement with the cycle counts that have been made.
- Two of ten cyclists agree very much to the statement that there are fewer cars, and four of ten feel the traffic environment is very much or somewhat better.
- A majority of cyclists experience no difference in safety, accessibility or number of conflicts with other road users. A small number experience a worsened situation and approximately the same number experience an improvement.
- Cyclists experience that accessibility and safety has improved more in the *inner city* than at the four places. This may have to do with the prevailing general decline in car traffic in the inner city, where the decrease on *small inner city streets* was unexpectedly large – about as large as on the major inner city streets.
- The hypothesis about improved street environment was thus partially confirmed. Since the travel pattern study cannot be used to analyse pedestrian and cycle travel it is not possible to say anything about the other hypotheses, that is whether it is the shorter car trips across the charge zone that have been replaced by pedestrian and cycle traffic and whether the increases in travel by public transport have caused more people to use a combination of cycle and public transport.

4. Parking

Introduction

The Stockholm Trial may have an affect on motorists' utilisation of park-and-ride facilities. In the study presented in this report, the following hypotheses were tested:

- More people will be parking in park-and-ride sites as a result of the Stockholm Trial.
- Fewer people will be parking in multi-storey car parks in the inner city as a result of the Stockholm Trial.

Method

To determine possible changes in utilisation of park-and-ride facilities we chose to compare the number of vehicles parked on the sites at certain times. A manual count of the number of vehicles in park-and-ride sites was made during spring and autumn 2005 and spring 2006. The study includes a fairly large selection of park-and-ride facilities belonging to Stockholm Transport (SL), all of the park-and-ride sites belonging to Stockholm Parkering AB and a selection of Stockholm Parkering's multi-storey car parks.

Findings

The number of parked vehicles in park-and-ride sites in Stockholm County as a whole has increased by 23%, from about 7,750 (spring 2005) to about 9,560 (spring 2006) calculated as an average per month. The corresponding figure for Stockholm County, excluding the City of Stockholm, is an increase of 21%. The total number of parked vehicles in park-and-ride facilities owned by Stockholm Parkering AB (in the City of Stockholm) has increased by 31%.

In park-and-ride facilities run by SL there has been a statistically significant increase in the number of parked vehicles in 10 of all 22 municipalities. The total increase is an average of next to 1,200 vehicles a month. The total number of spaces in park-and-ride facilities has increased by slightly over 1,800 between spring 2005 and spring 2006.

In park-and-ride facilities owned by Stockholm Parkering AB, 20 of 32 show a statistically significant difference in the number of parked vehicles between spring 2005 and spring 2006. For three of them there is a decrease and for the other 17 an increase. Nine new park-and-ride facilities have been added during the period and one has been closed. The total difference is an increase on average of about 600 vehicles a month. Some 1,050 new spaces in park-and-ride facilities have been created between spring 2005 and spring 2006.

Table 1. below shows how the number of parked vehicles in park-and-ride facilities changed from spring 2005 to spring 2006.

Table 1 Number of parked vehicles and number of park-and-ride parking spaces in 2005 compared with 2006. Selected park-and-ride facilities in Stockholm County were studied.

	Total	SL	Stockholm Parkering
Number of parked vehicles, spring* 2005 (average per month)	7,751	5,742	2,009
Number of parked vehicles, autumn** 2005 (average per month)	8,418	6,367	2,051
Number of parked vehicles, Oct-Dec 2005 (average per month)	8,542	6,464	2,078
Number of parked vehicles, Jan-March 2006 (average per month)	8,764	6,297	2,467
Number of parked vehicles, spring* 2006 (average per month)	9,559	6,924	2,635
Increase in number of parked vehicles from spring* 2005 to spring* 2006 (average per month)	1,824	1,198	626
Increase in number of parked vehicles from spring* 2005 to spring* 2006 (percent)	23%	21%	31%
Occupancy level, spring* 2005	78%	81%	69%
Occupancy level, autumn** 2005	76%	78%	70%
Occupancy level, spring* 2006	74%	78%	66%
Number of new parking spaces from spring* 2005 to spring* 2006	2,886	1,832	1,054
Increase in number of parking spaces from spring* 2005 to spring* 2006 (percent)	29%	26%	36%
Proportion of increase between spring* 2005 and spring* 2006 in number of parking spaces that were part of the Stockholm Trial	About 80%	About 80%	About 80%

*Average during the months of April and May **Average during the months of September and October

The study includes eight multi-storey car parks, six of which are located within the zone for the congestion tax. Two had a statistically significant change in the number of rented parking spaces after the introduction of the congestion tax, one an increase and the other a decrease. Both were within the zone for the congestion tax. There are signs of reduced income from visitors' spaces.

In Table 1.2 below the number of parked vehicles and parking spaces in 2005 as compared with 2006 in a selection of multi-storey car parks run by Stockholm Parkering is presented.

Table 2. *Number of parked vehicles and park-and-ride parking spaces in 2005 compared with 2006 at a selection of Stockholm Parkering's multi-storey car parks.*

	Total	Inside zone for congestion tax	Outside zone for congestion tax
Number of parked vehicles, spring 2005 (average per month)	1,063	874	189
Number of parked vehicles, spring 2006 (average per month)	1,131	952	179
Change in number of parked vehicles from spring 2005 to spring 2006 (average per month)	68	78	-10
Change in number of parked vehicles from spring 2005 to spring 2006 (percent)	1%	1%	-1%
Occupancy rate, spring 2005	71%	78%	52%
Occupancy rate, spring 2006	74%	81%	50%
Change in number of parking spaces for rent from spring 2005 to spring 2006	+46	+46	0
Change in number of parking spaces for rent from spring 2005 to spring 2006 (percent)	3%	4%	0%

Conclusions

The increase in the number of parked vehicles that occurred between spring 2005 and spring 2006 shows that the hypothesis that more people would park and ride as a result of the Stockholm Trial was correct. The relatively small changes between the periods of October-December 2005 and January-March 2006 show that the creation of more park-and-ride facilities and an increase in the number of park-and-ride parking spaces were of greater significance to park-and-ride utilisation than the congestion tax itself. Investments in public transport have probably also played a role in the increased use of park-and-ride facilities.

The hypothesis that fewer people would park in the multi-storey car parks in the inner city as a result of the Stockholm Trial has not been confirmed.

5. Travel patterns

5.1 Travel pattern study in Stockholm County

Introduction

To study in what way trips³ taken by Stockholm County inhabitants have been affected by the Stockholm Trial, an extensive travel pattern study was carried out in the county (Trivector, 2006:67). The study was made both *before* the implementation of the trial and *during* it.

Traffic counts and other studies in the evaluation have already shown a decline in car travel. The travel pattern study makes it possible to gain knowledge about *the way* in which the population has adapted its travel. Are they switching from car to public transport? Are they altering the time for their travel? Are they making fewer trips?

Are other goals for the trips being chosen?

To facilitate reading, the wording “trips *within and to/from* Stockholm County” is shortened below to “trips *in the county*.” All trips presented here, unless otherwise stated, are ones made by inhabitants in Stockholm County.

Seasonal variations have made it hard to carry out the evaluation

The evaluation of the travel pattern study was made difficult by the fact that the study before the trial was done during autumn and the study after the trial during spring. The plan from the beginning was to carry out the two studies in autumn 2004 and 2005, but this was impossible since the trial period with the congestion tax wasn't started until January 2006.

Normal seasonal variation means that more trips are made in spring than in autumn. The number of trips varies depending on the purpose of the trip and what mode of transport is chosen. For example cycle trips are considerably more sensitive to season and weather than car trips are, and trips such as leisure travel are considerably more sensitive than trips to and from work or school. This is knowledge we have in Sweden through recurring travel pattern studies, RES, that were used to distinguish the effects of seasons in the travel pattern studies carried out autumn 2004 compared to spring 2006.

When possible we added comments about the impact of seasonal variations on the difference between the two travel pattern studies. There is reliable information about seasonal variations for travel in the county as a whole and for the number of vehicles across, for example, the inner city zone. When it comes to seasonal differences for different groups' travel or

³Here, “trip” denotes a transfer made by one person from one place to another with the purpose of carrying out a purpose. All transfers are counted – regardless of whether they take place by foot, cycle, car or public transport.

for different travel relations, the information is often uncertain and also highly variable as well. This means for example that it is not possible to isolate the impact of the Stockholm Trial on travel by individual groups.

The travel pattern study has been supplemented with non-response investigations to see how well those who answered the travel pattern questionnaire represent the entire population of the county. The non-response analyses show that there are differences in travel patterns between the non-response group and the group that responded but that this did not affect the conclusions made about *changed* travel patterns.

Results and Conclusions

Car trips of county inhabitants across the charge zone have declined and public transport has increased

The trial with the congestion tax has entailed a reduction of approximately 20 percent in car trips by Stockholm County's inhabitants across the congestion charge zone. The decline may have been reinforced by the rise in petrol price. The car trips that percentage-wise declined the most were trips between the northern and southern halves of the county, particularly trips through the inner city. The decline in county inhabitants' car trips across the charge zone during one weekday day constitute more than 80,000 vehicle passages through the zone. The decrease is entirely in line with traffic measurements across the charge zone.

Public transport travel across the zone has increased by about 5 percent due to the Stockholm Trial. Recalculated as passengers passing through the zone on public transport the increase is equivalent to over 30,000 due to the Stockholm Trial. This figure is somewhat lower than the one supplied by SL in its report, where the estimate made is equivalent to 45,000 passages across the charge zone.

Travel by foot or cycle across the charge zone has probably not been affected – or very little – by the trial during the periods for which the travel pattern study applies. Travel by foot or cycle shows considerable seasonal variation, with high fluctuations according to the weather. The evaluation of pedestrian and cycle trips could not show that any change was caused by the trial.

Table 1 Number of trips passing across the charge zone at least once, with respective mode of transport, during one weekday day.

Number of trips across the charge zone during one weekday day						
	By foot	Cycle	Car	Public transport	Other	Total
TPS 2004	21,000	40,000	377,000	709,000	41,000	1 188,000
TPS 2006	22,000	9,000	286,000	734,000	27,000	1 078,000
Change in percentage	(+6%)	-78%	-24%	(+4%)	-34%	-9%
Statistically significant difference	No	-31,000	-92,000	25,000	-14,000	-110,000
<i>Estimated seasonal/weather variation</i>	-	-	-5%	-1%	-	

Where did the “cancelled” car trips go?

Seasonal variation, as mentioned above, causes considerable differences in travel relations, travel objectives and modes of transport. This makes it impossible to trace in detail what happened with every car trip that disappeared across the congestion zone, or exactly what happened with each trip carried out with a particular objective. But assuming that travel across the charge zone to and from work and school is basically bound in time and place, it is possible to trace some adaptation patterns. The results from trips to and from work and school are clear-cut and represent about half of the decline of car trips across the charge zone.

The number of trips to and from work and school across the charge zone have not declined as a result of the trial. Nor is there – neither in this study or in the others included in the evaluation of the Stockholm Trial – anything that indicates an increase in telecommuting as a result of the trial. There has been no rise in car pooling either. Both the travel pattern study and the manual traffic counts show that the number of people per private car remains at a steady figure of 1.26-1.27. Moreover there is no evidence of a marked redistribution of trips to other times of the day in an effort to avoid the charge periods.

The co-ordination of carrying out several objectives in a travel chain may have increased slightly (about as much for all groups and modes of transport), but the differences are very small. Co-ordination means for example buying food on the way home from work instead of first going home and then going out shopping, requiring only three trips instead of four.

A majority of the “cancelled” car trips to and from work and school across the charge zone have been transferred to public transport as a result of the Stockholm Trial. The exception is the relatively small number of work journeys between the northern and southern parts of the county, which used to go through the inner city but now go on the Essingeleden bypass.

There has however been a decline in public transport travel to carry out other objectives than getting to work/school, assuming the seasonal variation has been normal between the measurement periods. This means that trips carried out with the objective of buying something, obtaining service or doing something during leisure time have been adapted according to other patterns than a change in mode of transport. Car trips across the charge zone, apart from work or school trips, have instead shifted their destination/starting point or taken another route, or simply been cancelled.

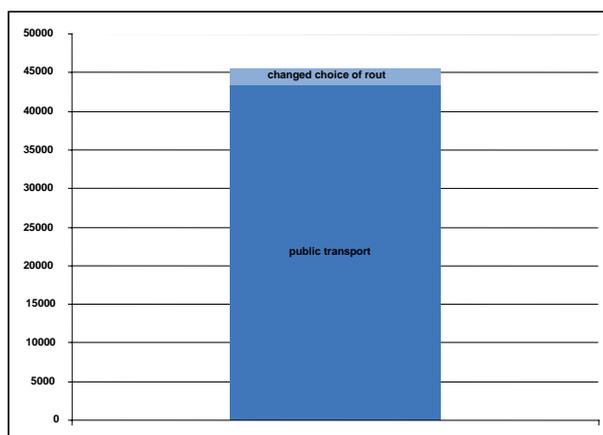


Figure 1 Trips across the charge zone to and from work and school no longer taken by car during a weekday day.

Trips for buying something or obtaining service, along with business trips, have probably declined somewhat as a combined effect of the Stockholm Trial and the rise in petrol price. It is only trips with these purposes that visibly differ from normal seasonal variations in the county. The values used to make comparisons between the travel pattern study and RES⁴ have not been measured in exactly the same way, for which reason no exact effects can or should be accounted for.

Table 2 Number of car trips through charge zone at least once on a weekday day, with specified objective.

Number of car trips through charge zone during one weekday day							
	Work/ school	Business trip	Purchase/ service	Leisure	Going home	Other	Total
TPS 2004	100,000	51,000	44,000	43,000	110,000	29,000	377,000
TPS 2006	78,000	36,000	32,000	33,000	87,000	19,000	286,000
Change in percentage	-22%	-30%	-27%	-23%	-21%	-33%	-24%
Statistically significant difference	-22,000	-15,000	-12,000	-10,000	-23,000	-9,000	-91,000
Estimated seasonal variation							-5%

⁴ Nationella Resvaneundersökningen (National Travel Pattern Study). Analyses based on partial trips during years 1995–2001.

Table 3 Number of public transport trips through charge zone at least once on a weekday day, with specified objective.

Number of trips on public transport through charge zone during one weekday day							
	Work/school	Business trip	Purchase/service	Leisure	Going home	Other	Total
TPS 2004	252,000	25,000	64,000	83,000	267,000	18,000	709,000
TPS 2006	274,000	22,000	59,000	78,000	283,000	18,000	734,000
Change in percentage	+9%	(-10%)	(-7%)	(-6%)	(+6%)	(-1%)	(+4%)
Statistically significant difference	22,000	No	No	No	No	No	+25,000
Seasonal variation							-1%

Groups that reduced their number of car trips through the congestion zone

It is not possible to trace how the measured changes for various groups between measurement periods in the travel pattern study were affected precisely by the Stockholm Trial, since the seasonal influence varies greatly among different groups, relations and modes of transport. (Moreover there are no reliable figures for travel across the charge zone distributed according to type of objective.) The reported differences include seasonal variation, which thus cannot be assumed to look the same for the different groups. Even if it is not possible to separate the effects of the trial from other causes it is interesting to study who changed their behaviour the most.

All geographical and socio-economical groups reduced the number of their car trips across the charge zone between autumn 2004 and spring 2006, regardless of charge hour. The size of the reduction however is different for different groups. Jobseekers, students and pensioners are those who reduced the number of their car trips the most. Even during charge hours all groups reduced their car trips across the charge zone in spring 2006 compared to autumn 2004. Note however that the comparison includes seasonal variations, which may well shift from group to group.

Percentage-wise, those who reduced their car travel across the charge zone the most were students, jobseekers and adults with older children. Regarding differences between people with different spending capacities, it was those with a medium spending capacity who most greatly reduced their number of car trips across the charge zone during the charge hours. Men made twice as many car trips as women across the charge zone during charge hours. On the other hand men and women had reduced their car trips through the zone during charge hours equally much in spring 2006 as compared with autumn 2004.

Men who live inside the charge zone answer for the largest number of car trips per person across the charge zone during charge hours in both 2004 and 2006 (despite a considerable decline). The same thing applies to adults with children, especially those who live within the zone.

Effects of the congestion tax hardly visible in the county's total travel

The “cancelled” car trips across the charge zone that were a result of the Stockholm Trial make up a very small share of the total number of trips (all modes of transport combined) that inhabitants in the county make, namely about 2 percent during a weekday day. Of all the car trips in the county the decline across the charge zone constitutes slightly over 4 percent – which is also a very small share.

The total number of trips on a weekday day in the county has declined somewhat more between the measurement periods than what is normal between the seasons. The decline – assuming normal seasonal variation – is about 3 percent, which is equivalent to about twice as many trips as the decline across the charge zone. However it is very uncertain, based on these results, that the total number of kilometres in the county has changed.

Table 4 Total number of county inhabitants' trips in the county by various modes of transport per weekday day.

Total number of trips in the county per weekday day						
	By foot	Cycle	Car	Public transport	Other	Total
TPS 2004	751,000	295,000	2,142,000	1,378,000	98,000	4,664,000
TPS 2006	686,000	45,000	1 806,000	1 424,000	63,000	4 024,000
Change in percentage	-9%	-85%	-16%	+3%	-36%	-14%
Statistically significant difference	-65,000	-250,000	-336,000	+46,000	- 35,000	-640,000
Seasonal variation RES	8%	-44%	-16%	-1%	-52%	-11%

5.2 Travel in the stockholm/mälaren region

Background

Those who live and work in Stockholm County are affected by the Stockholm Trial more than those who live in other counties in the Stockholm/Mälaren region. From the viewpoint of the Stockholm/Mälaren region being an integrated housing and labour market, however, it is important to try to determine the effects of the Stockholm Trial on those who live outside the county border. During the month of March 2006 an average of 350,000 vehicles passed one of the control points for the congestion tax. Of these, some 4,000 were from areas outside Stockholm County, an equivalent of about 1%.

Assignment

The assignment was to carry out a study of those who commute to work over the county border into central parts of Stockholm and who are thereby affected by the congestion tax. The object of the study was to identify possible changes in this group's journeys to/from work in terms of number of journeys and choice of means of transport. A total of 875 people took part in the study.

Main findings

After the start of the trial with the congestion tax the number of journeys to/from work by car during one week declined by about 8%. The number of journeys to/from work on public transport had increased by about 1%. Journeys to/from work via a combination of car/public transport rose by 1.5%. In total there was a decline in the number of journeys to/from work during one week of about 1%.

Conclusion

Besides the Stockholm Trial, including implementation of the congestion tax in spring 2006, there was a significant rise in the price of petrol of SEK 0.85 per litre from April 2005 to April 2006.⁵ The average length of travel by car was about 100 km. Based on a consumption of 0.09 litre petrol/km, the increase in the price of petrol meant an excess cost of about SEK 15 return.

The congestion tax in combination with an increase in petrol price, or each factor by itself, may be the explanation behind the decline in the number of journeys to/from work by car. Therefore it is not possible to say that the congestion tax connected to the Stockholm Trial is the reason for the decline.

⁵ Source: Statistics Sweden

5.3 In-commuters' travel patterns

The study focuses on people who have their place of work in the Stockholm inner city but who live outside of it, while still within Stockholm County. These people are called “in-commuters” in the report. There was only a small difference in the travel patterns of in-commuters from autumn 2004 to autumn 2005. Travel by car has fallen somewhat but there has not been a corresponding rise in travel by public transport, despite the investments carried out within the framework of the Stockholm Trial.

Since car travel is by and large unchanged for the trips that extended public transport were aimed at, this indicates that the investment in public transport did not persuade car commuters to change their travel patterns before the trial with the congestion tax. However the extended public transport system attracted certain groups of in-commuters to use more public transport in 2005 as compared to 2004. These groups are in-commuters with children, in-commuters with average spending capacity and in-commuters who were born in foreign countries.

Investments in public transport were made within the framework of the Stockholm Trial. Among other things, new bus services were started from the southern and northern suburbs directly to the inner city in the morning and back again in the afternoon. In the inner city, too, new bus routes were introduced. Throughout the county there has been a total increase in the number of departures in both rail transit and bus services.

The goal of the study was to determine the effect of extended public transport on travel before the introduction of the congestion tax. To do this, travel patterns in autumn 2004 were compared with those in autumn 2005.

What changes are there in in-commuters' travel?

The analysis shows a slight decline in in-commuters' car travel from 2004 to 2005. There has been an increase in cycle trips and there is a tendency towards an increase in public transport but the latter increase is not significant. In total in-commuters make about as many trips per person and weekday before as after the investments in extended public transport.

How have different groups of in-commuters been affected?

Even if in-commuters as a whole have not increased their use of public transport, certain smaller groups of in-commuters have. A larger proportion of in-commuters with children, in-commuters with average spending capacity and in-commuters born in foreign countries took public transport through the future congestion-charge zone during the charge period in 2005 as compared with 2004. A similar reduction in car travel for these groups, however, is not as clear-cut.

6. Road safety

The analysis of the effect of the Stockholm Trial on road safety in Stockholm County consists of two parts: an analysis of personal injuries and traffic accidents and an analysis of factors that indirectly affect road safety. Research shows that road safety is primarily affected by changes in traffic volume, speed level and road users' choice of road. It was possible to study changes in two of the three factors: traffic volume and speed levels.

Before making the analysis of the effects of the Stockholm Trial on road safety the following hypotheses were proposed:

- A reduced number of injuries within the congestion-tax zone
- A reduced number of accidents caused by rear-end collisions as a result of reduced congestion
- A reduced number of personal injury accidents (PIAs) as a result of reduced vehicle kilometres travelled (VKT)/reduced traffic volume
- A rise in the number of PIAs as a result of increased speed levels

The assessment of the Stockholm Trial's effect on road safety is based on data before and during the trial period with the congestion tax. The following indicators were analysed:

- Registered change in number of fatalities and injuries
- Registered change in number of accidents involving rear-end collisions
- Estimated change in number of PIAs as a result of changes in VKT
- Estimated change in number of personal injury and fatal accidents as a result of changes in traffic volume
- Estimated change in number of PIAs as a result of changes in travel speed
- Estimated change in number of personal injury and fatal accidents as a result of changes in point speeds

Neither within nor outside the congestion-tax zone could any statistically significant change in the total number of police-reported fatalities and personal injuries be established for the first quarter of 2006. The same applies for the number of registered accidents involving rear-end collisions. The primary reason for the inability to see any changes in the number of personal injuries and traffic accidents is that the study period was entirely too short. The hypotheses that there would be a reduced number of registered cases of injuries and accidents involving rear-end collisions can neither be confirmed nor repudiated. See Table 1 below.

Table 1. Change in number of police-reported cases of injury and traffic accidents

Indicator	Before trial period with congestion tax ¹	During trial period with congestion tax ²	Change	Hypothesis	Hypothesis confirmed
Police-reported fatalities and personal injuries	1,087	1,044	Decrease not significant	Will decrease within the congestion-tax zone	No
Accidents involving rear-end collisions	162	184	Increase not significant	Will increase	No

¹ Mean value for first quarters 2003-2005

² Denotes first quarter 2006

The estimated decrease in VKT means a decrease in the expected number of PIAs of 9% to 18% within the congestion-tax zone and nearly 2% within Stockholm County. The measured decrease in traffic volume means a decrease in the expected number of PIAs on essentially all types of traffic routes. The hypotheses that the estimated number of PIAs will decrease as a consequence of reduced VKT and traffic volume can be considered confirmed. See Table 2 below.

The reduction in traffic has entailed higher speeds, especially during congestion-charge hours. The rise in speed level means an increase in the expected number of PIAs on most types of traffic routes. The hypotheses that the estimated number of PIAs will increase as a result of increased speeds can be considered confirmed. See Table 2 below.

Table 2. Change in estimated number of personal injury accidents

Indicator	Change in estimated number of PIAs within the congestion-tax zone	Total change in estimated number of PIAs within the county	Hypothesis	Hypothesis confirmed
Vehicle kilometres travelled (VKT)	Reduction of 9-18% based on VTI's calculations	Reduction of about 2% based on calculations by Swedish Road Administration, Consulting Services	Will decrease	Yes, within congestion-tax zone
Traffic volumes	Reduction of 4-5% ¹	Reduction of 0-11% ²	Will decrease	Yes
Travel speed	Believed to increase. ¹ Size of increase cannot be established	Believed to increase. Size of increase cannot be established	Will increase	Yes
Point speed	Increase by about 3% ¹	Varies between decrease of 1% and increase of 5%	Will increase	Yes

¹ Denotes road types: inner-city streets and inner-city routes. Changes within these links do not give a comprehensive/total picture of developments within the congestion-tax zone.

² Denotes road types: inner-city streets, inner-city routes, Route E4/Essingeleden bypass, inner approach, outer approach and link road.

The coordinated effect of the Stockholm Trial on road safety is judged to be positive, as the positive effect of reduced traffic is expected to be greater than the negative effect of increased speeds. The positive effect occurs primarily within the congestion-tax zone and connected approach roads. A cautious estimate is that the Stockholm Trial has meant a reduction in the number of personal injury accidents of 5% to 10% within the congestion-tax zone, which is the equivalent of a decrease of between 40 and 70 PIAs per year.

7. Air quality

The Stockholm Congestion Charging Trial runs between January 3 and July 31 2006. The main aim of the trial is to reduce congestion, increase access and improve the environment.

In this report an account is given of the effects of the Stockholm Trial on emissions and levels of air pollutants in Stockholm and their long-term implications for Stockholmers' health. The report focuses on inhalable particles (PM₁₀) and nitrogen oxides (NO_x and NO₂), but emission calculations have also been carried out for other air pollutants such as the greenhouse gas carbon dioxide. The evaluation of the environmental effects primarily comprises *calculations* of how emissions and levels of air pollution have been influenced by the Stockholm Trial. The calculations are based on those traffic analyses made in connection with the trial. Before and during the trial air quality has also been monitored at 20 or so locations in the Greater Stockholm area.

Compared with an imagined situation for the entire year of 2006 without the Stockholm Trial, it is calculated that emissions of nitrogen oxides in the Greater Stockholm area (1.44 million inhabitants, 35 km x 35 km) have decreased by approximately 55 tons. For particles, PM₁₀, the corresponding reduction is 30 tons, of which approximately 2/3 is the result of reductions in emissions in the inner city. There is a reduction both in particles formed by erosion of the road surface and of those emitted from exhaust pipes. Carbon dioxide emissions in the Greater Stockholm area are calculated to have fallen by approximately 41,000 tons.

For the Greater Stockholm area the percentage reductions in emissions are calculated at approx. 1-3 %, for the City of Stockholm approx. 3-5 % and for Stockholm's inner city approx. 8-14 %. Emissions also include the effects of the increased bus traffic resulting from the Stockholm Trial (including direct buses to and from the inner city).

The total reduction in emissions means that the interim target of the Stockholm Trial, namely that emissions should be reduced, has been achieved.

Table S1. Calculated reductions in emissions from road traffic in Stockholm for a situation for 2006 with/without the Stockholm Trial .

	Inner city:		City of Stockholm:		Greater Stockholm*:	
	tons/year	per cent	tons/year	per cent	tons/year	per cent
Nitrogen oxides. NO _x	45	-8.5 %	47	-2.7 %	55	-1.3 %
Carbon monoxide. CO	670	-14 %	710	-5.1 %	770	-2.9 %
Particles. PM ₁₀ total	21	-13 %	23	-3.4 %	30	- 1.5 %
“erosion particles”	19	-13 %	21	-3.3 %	28	-1.5 %
“exhaust particles”	1.8	-12 %	1.8	-4.4 %	2.1	-2.4 %
Volatile organic compounds .VOC	110	-14 %	120	-5.2 %	130	-2.9 %
benzene. C ₆ H ₆	3.4	-14 %	3.6	-5.3 %	3.8	-3.0 %
Carbon dioxide. CO ₂	36,000	-13 %	38,000	-5.4 %	41,000	-2.7 %

* defined as an area of 35 km x 35 km across central Stockholm.

Reduced emissions from road traffic in Stockholm mean that the air has become cleaner. The average levels of nitrogen oxides (NO_x) are calculated to have decreased by at most 5-10 µg/m³ (micrograms per cubic metre of air) and levels of particles, PM₁₀, by at most 2-3 µg/m³. The greatest improvements in air quality were obtained along the Klarastrandsleden bypass, Centralbron, Valhallavägen and Sveavägen, and at the entrances to the Söderleden tunnel (Figure S1).

The levels of air pollution have increased in an area around the Essingeleden bypass and the Södra Länken bypass tunnel, but considerably more Stockholmers now experience reductions in air pollution and better air quality compared with those who experience increased levels of pollution.

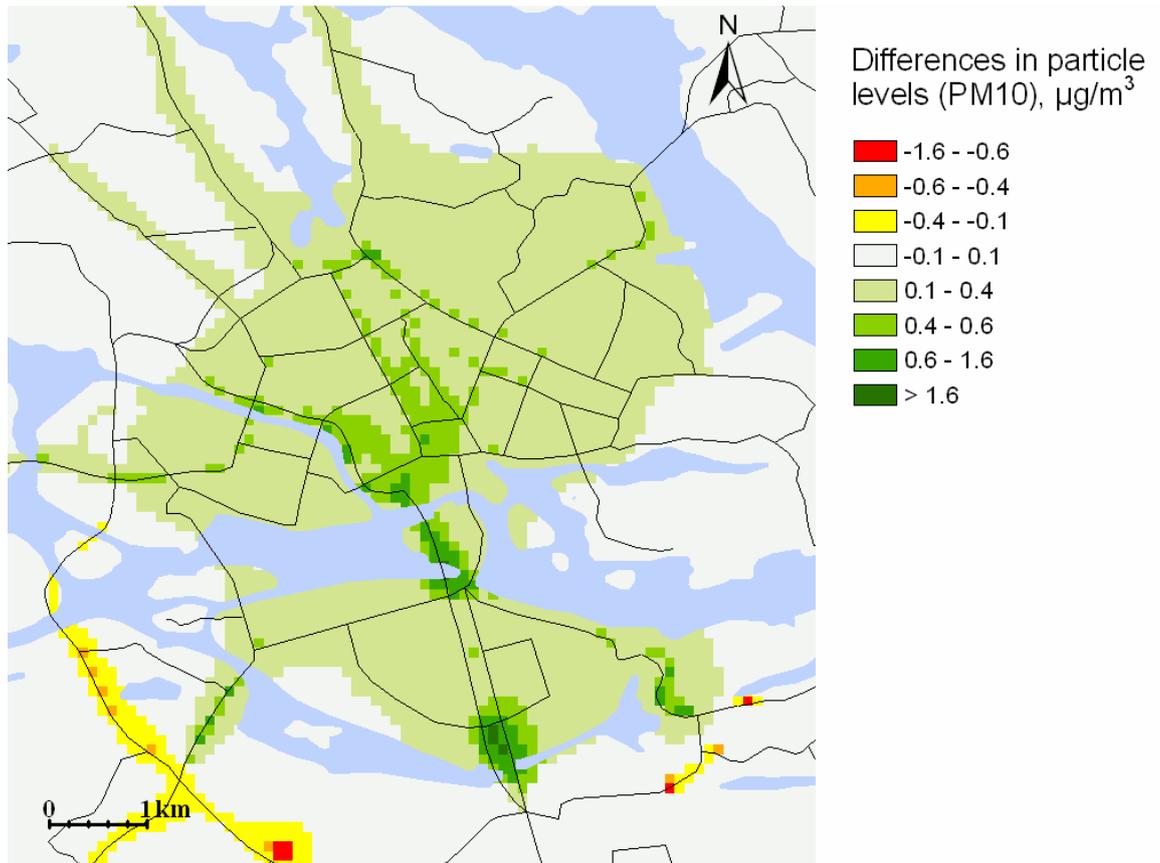


Figure S1. Changes in levels of particles (PM₁₀, mean annual levels) with the Stockholm Trial compared with levels without the congestion charge for 2006. Within the green areas the levels are lower, within yellow to red areas there is an increase in levels. In the inner city changes refer to rooftop level.

On Hornsgatan the levels of nitrogen oxides (NO_x) at street level are calculated to have fallen by approximately 7-8 %, levels of nitrogen (NO₂) by approximately 3-4 % and levels of particles (PM₁₀) by 5 %. The improvement is sufficient that the environmental quality standard (to protect public health) as regards the mean annual value for particles, PM₁₀, will not be exceeded on Hornsgatan. On the other hand, environmental quality standards are still being exceeded as regards high daily median values both for particles, PM₁₀ and for nitrogen dioxide. Environmental quality standards are legally binding national stipulations whose primary aim is to protect the public against long-term health effects, whilst daily median values (and hourly median values) refer to protection against acute health effects.

On Sveavägen the levels of nitrogen oxides (NO_x) at street level are calculated to have fallen by 3 %, levels of nitrogen dioxide (NO₂) by approx. 1-2 % and levels of particles (PM₁₀) by 4 %. The improvement is sufficient for the environmental quality standard for the annual mean value for nitrogen dioxide, NO₂, not to be exceeded on Sveavägen. Just as on Hornsgatan, however, the environmental quality standards for high daily

median values are still being exceeded both for particles, PM₁₀ and for nitrogen dioxide.

On Norrlandsgatan the levels of nitrogen oxides at street level are calculated to have fallen by 11 %, the levels of nitrogen dioxide (NO₂) by approximately 5-6 % and the levels of particles (PM₁₀) by 7 %. The improvement is sufficient for the environmental quality standard for the annual median value for nitrogen dioxide, NO₂, not to be exceeded on Norrlandsgatan. Here too the environmental quality standard is, however, exceeded as regards high daily median values both for particles, PM₁₀ and for nitrogen dioxide.

On S:t Eriksgatan (south of S:t Eriksbron bridge) the air quality is calculated to be unchanged at street level. A little more traffic and somewhat higher emissions are balanced by the fact that the urban background level of air pollutants has fallen. The environmental quality standard for annual median values is being met, but the standard for high daily median values of particles, PM₁₀ is being exceeded.

On Valhallavägen (NW of Lidingövägen) the levels of nitrogen oxides (NO_x) at street level are calculated to have fallen by 12 %, and the levels of nitrogen dioxide (NO₂) and particles (PM₁₀) by approximately 7-8 %. The improvement is not sufficient to meet the environmental quality standard for high daily median values of particles, PM₁₀, on Valhallavägen.

Along the Essingeleden bypass the environmental quality standard for protecting public health is also being exceeded. The increased traffic on this road, with the Stockholm Trial, is calculated as meaning rather higher levels of air pollutants, as has been mentioned above. The increase in levels for an average 24-hour period is approximately 3 µg/m³ (micrograms per cubic metre of air) for nitrogen oxides, NO_x, and up to approximately 2 µg/m³ for particles, PM₁₀. In order to meet the environmental quality standards for particles along the Essingeleden bypass, major reductions in emissions are needed.

For many inner-city streets with high levels of air pollutants the situation has been improved by the Stockholm Trial. Environmental quality standards for the protection of public health will be met to a greater extent than previously as a result of reduced traffic. The effect of this trial is, however, not sufficient for environmental quality standards to be met everywhere in Stockholm (apart from on inner city streets, environmental quality standards are exceeded along the city's major approach roads). To meet the standards requires greater reductions in traffic to cut emissions from road traffic.

The reduction in emissions and the general improvement of air quality in Stockholm means that Stockholmers' health will improve in the long-term (i.e. with the permanent introduction of a congestion charge). In long-term exposure to air pollutants even relatively small improvements in air quality can provide appreciable health benefits for a large population. International research ascribes *reduced mortality* as the most important of

these health benefits. Early death as a result of long-term exposure to air pollutants can, for example, result from cardiovascular diseases and lung cancer.

In order to quantify the effects of the Stockholm Trial as regards its long-term significance for Stockholmers' mortality, a Norwegian study has been used. On the basis of this study it is calculated that improvements in air quality in Stockholm will lead to approximately 20-25 fewer early deaths per annum for Stockholm's inner-city. In total for the entire Stockholm area (1.44 million inhabitants, 35 x 35 km) it is calculated that there will be between 25 and 20 fewer early deaths per annum as a result of the cleaner air. Apart from the long-term effects on Stockholmers' mortality, vehicle emissions also have an effect on the occurrence of illnesses as well as aggravating respiratory conditions in individuals who are prone to these. The cleaner air resulting from the Stockholm Trial means fewer admissions to hospital and fewer cases of distress experiences, i.e. people experiencing the air as irritating, evil-smelling or dirty.

Comparisons between levels of air pollutants that have been *measured* during the first four months of the full-scale trial (the period from January to April 2006) with corresponding months in 2003, 2004 and 2005 show that the variations in levels of pollutants between different years can be significant. This depends to a great extent on the fact that meteorological conditions are very important when studying a short period of time. Particle levels in the air, for example, depend to a high degree on the humidity of the road surfaces. During the spring of 2006 Stockholm received a large amount of precipitation and the snow melted late, which caused particle levels to be unusually low. The influence of the weather means that the total levels measured during the Stockholm Trial cannot provide quantitative information on how significant the reductions in traffic emissions have been for levels of air pollutants. In the long term, for example if the Stockholm Trial becomes permanent, air quality in Stockholm will therefore be affected mostly by reductions in emissions.

A more detailed analysis of the measurements on the inner-city streets of Hornsgatan and Sveavägen during the first four months of 2005 and 2006 shows that the contribution of traffic emissions to nitrogen oxide levels has decreased. However, contributions to emissions from the new direct buses could at certain times be proven in the measurements on Sveavägen.

Additional results

In November 2006 SLB Analys compiled longer time series for the rounds of monitoring work and calculations that formed the basis of this chapter. This data is available in SLB's report 2006:4. These new values were very consistent with the results from spring 2006, and meant that SLB did not need to alter the conclusions made previously. They were accurate.

8. Emission calculations

A reduction in vehicle traffic in the inner city is one of the main aims of the Stockholm Trial. This report sets out to study the resulting changes in exhaust emissions. In order to compare emissions with and without the congestion charge, approximations need to be used. For this the emission model ARTEMIS has been applied. This is a new model developed within the framework of an EU project. ARTEMIS is presently being implemented and the EMV model at the same time being phased out. With the model as a point of reference, a central question has been formulated:

- How have emissions of CO₂, NO_x, non-methane hydrocarbons and PM₁₀ for exhaust particles changed in Stockholm County excluding the charge zone, the City of Stockholm within the charge zone, and along major routes after the introduction of the Stockholm Trial?

The development of ARTEMIS (Assessment and Reliability of Transport Emission Models and Inventory Systems) is based on an extensive programme of monitoring. Based on this emission factors (emission per km driven) have been described in a number of drive-cycles which represent typical European driving conditions. The calculated emissions are grouped into hot emissions created during driving, cold emissions on start up with an engine that is not completely warmed up, and evaporative emissions, which are given off by both stationary and moving vehicles through vaporisation. Two main groups of input data are required in this model – data on traffic mileage (number of kilometres driven) and data on vehicle composition for the total traffic mileage driven.

Vehicles are grouped into passenger cars, light commercial vehicles, heavy goods vehicles, town buses and long-distance coaches. These five main groups of vehicles are further divided into subgroups by e.g. cubic capacity and age distribution. Data on the numerical composition of vehicles and their properties in Stockholm's inner city and in Stockholm County are taken from the Swedish Motor-Car Registry relating to January 2006.

In the current case separate calculations of emissions have been made for Stockholm County **excluding the charge zone**, the congestion charge zone, the Essingeleden bypass, the Klarastrandsleden bypass, Hornsgatan, Valhallavägen and St. Eriksgatan. The calculations relate to the situation **with the congestion tax** which is compared with a hypothetical situation **without the congestion tax** (a so-called with/without study). The calculations with the congestion tax have been made for a weekday 24-hour period in April 2006 (in reality a Monday-Thursday 24 hour period). The situation without congestion tax has also been calculated for a weekday 24-hour period, but is based on calculated and metered traffic conditions in April 2005. The composition of the vehicle fleet is common to both occasions, and is represented by the Swedish Motor Car Registry for Stockholm County as above. Traffic mileage has been taken from statisti-

cal estimates and model-calculated values for the charge zone, and model calculations alone for the County. Data on the composition of the vehicle fleet has been acquired from manual metering of vehicles/vehicle types carried out by Ångpanneföreningen over those stretches of road where the control points were to be installed or already existed in April 2006. All the calculations of emissions were made for four different time intervals, 0600-0900, 0900-1500, 1500-1800 and 1800-0000.

Summary of results

1. Congestion charge zone

Traffic mileage within the congestion charge zone has fallen by **approximately 15 %** taken across the whole 24-hour period and by **more than 17 %** in the hours of peak traffic in the morning and afternoon. Table S1 shows traffic mileage with and without the congestion charge as well as the percentage change for each time period broken down by vehicle type. The categories town bus and long distance coach have been merged into one group in this return.

Table S1 Traffic mileage within the charge zone without and with the congestion charge and percentage changes in this. Divided into time periods and vehicle types.

Zone	Without congestion charge				
Time period	Pass.car	LCV	HGV	Bus	Total
0600-0900	318,689	49,238	12,406	7,366	387,699
0900-1500	584,455	105,466	30,028	12,451	732,400
1500-1800	393,950	50,743	6,920	9,687	461,300
1800-0600	546,258	38,630	6,640	12,072	603,600
0000-2400	1,843,352	244,077	55,994	41,576	2,185,000

Zone	With congestion charge				
Time period	Pass.car	LCV	HGV	Bus	Total
0600-0900	257,761	40,665	11,847	9,926	320,200
0900-1500	474,255	92,538	27,396	14,611	608,800
1500-1800	319,960	40,943	6,445	11,752	379,100
1800-0600	486,627	33,412	5,928	12,934	538,900
0000-2400	1,538,603	207,558	51,616	49,223	1,847,000

Difference in %				
Pass.car	LCV	HGV	Bus	Total
-19.1	-17.4	-4.5	34.8	-17.4
-18.9	-12.3	-8.8	17.3	-16.9
-18.8	-19.3	-6.9	21.3	-17.8
-10.9	-13.5	-10.7	7.1	-10.7
-16.5	-15.0	-7.8	18.4	-15.5

As is evident from the table, traffic mileage for passenger cars has decreased by approximately 16 %, which is more than the average decrease. But there has been a marked increase for buses with more than 18 % across the day and all of 35 % in the peak traffic period in the morning. This increase corresponds to approximately 8,000 km for buses across a

weekday 24-hour period. The method of determining the proportion of traffic mileage per vehicle category from the measurements carried out by Ångpanneföreningen presupposes the same average length of journey (within the zone) per category. But the buses that were added in 2006 may have a considerably shorter length of journey within the zone than those buses observed in 2004, and thus a shorter length of journey than other vehicles. This would, therefore, mean that 8,000 new bus kilometres is an overestimate, and that some of this traffic mileage should be added to the other categories.

In principal emissions of the different substances should be reduced to the same extent as the reduction in traffic mileage. But there is in addition a certain minor effect of the reduction in congestion. With the congestion charge there is a transfer of traffic mileage from an overloaded condition to not overloaded. This means rather less emissions per kilometre driven and can be illustrated by figure S1 below. The figure shows the percentage change in the emission factor per vehicle type for the emission of nitrogen oxides, NO_x, on the move, so-called hot emission (grams of NO_x per vehicle kilometre driven).

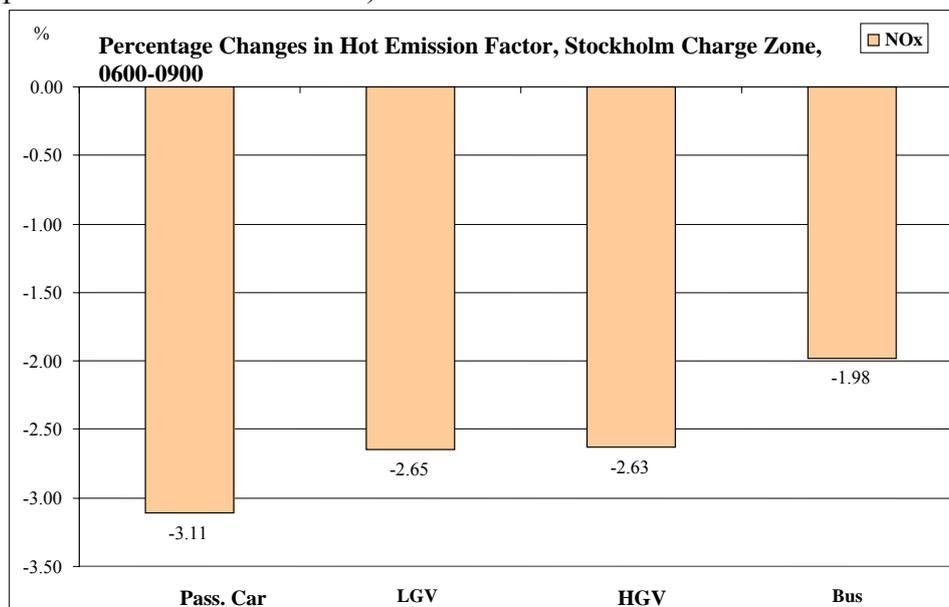


Figure S1 Percentage changes in emissions factors for NO_x without and with the congestion charge at a period of high traffic 0006-0900 for different vehicle types.

According to the figure the emissions of NO_x have fallen by 2-3 % per vehicle kilometre during the morning peak traffic. The corresponding values for the entire 24-hour period are 0.6-1 %.

Reduced congestion therefore results in a further reduction in emissions over and above that resulting from the reduction in traffic. But the composition of the traffic has changed with the introduction of the congestion charge; the proportion of passenger cars has fallen by 1.2 % points and the proportion of heavy vehicles (heavy goods vehicles and buses together) has increased by 1.1 % points. According to Table S1 traffic mile-

age for heavy vehicles has increased by more than 3,000 km. As heavy vehicles have a considerably worse performance as regards NO_x emissions, this results in a relative deterioration. A heavy truck produces on average 25 times greater NO_x emissions on the move than a passenger car, and a bus produces 28 times greater emissions within the zone. The changes in the composition of the vehicle fleet mean that it is not possible to achieve a reduction of NO_x emissions that is as big as the reduction in traffic. The net change, taking into account all the factors, is shown in Figure S2.

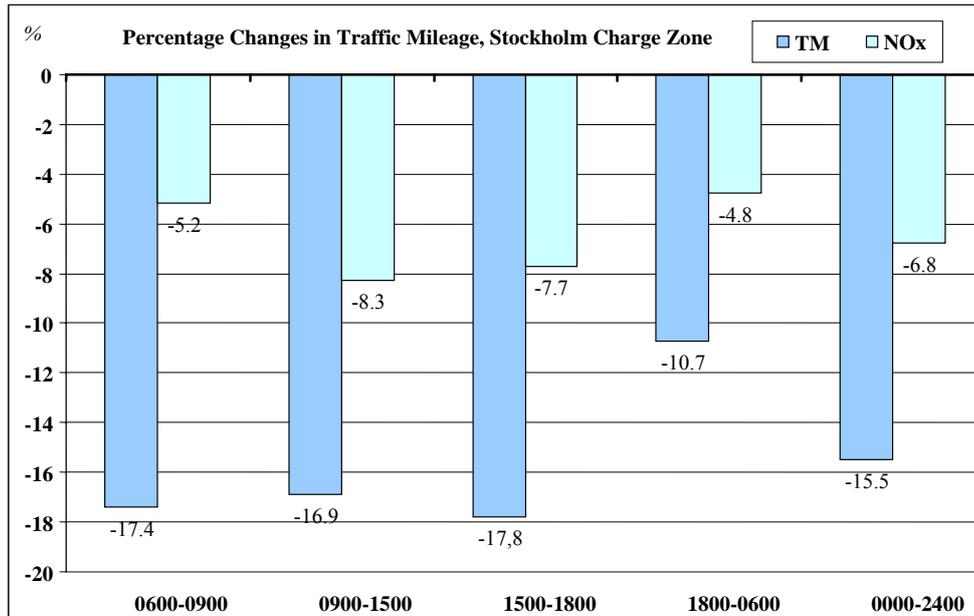


Figure S2 Percentage changes in NO_x emissions compared with changes in traffic.

Figure S2 shows the change in the total emissions of NO_x, both hot emission on the move and the effects of cold start-ups. Emissions from cold start-ups (only petrol driven vehicles) are proportional to the changes in traffic. The figure shows that the reduction in NO_x emissions is approximately 7 % across the entire 24-hour period, and 5-8 % during the daytime. It is open to discussion whether the emission factor in the ARTEMIS model for buses is too high. But actually it is not significant. A sensitivity analysis with a **halved emission factor** for buses reduces the emissions by a further 3-4.5 % points dependent on the time interval. In the same way the effect of the additional traffic mileage for buses has been analysed. If **half of the additional** 8,000 bus kilometres were to be transferred to traffic mileage for passenger cars and light commercial vehicles, the nitrogen oxide emissions would be reduced by a further 2 % points across the whole 24-hour period, and by 3.5 % points during the morning. A reasonable error assessment shows that the reduction in NO_x emissions can be a **maximum 10 %** throughout the 24-hour period (instead of the calculated 6.8 %) and a **maximum 9 %** during the morning (instead of the calculated 5.2 %).

Other exhaust emissions are, however, not at all as sensitive to the increased proportion of heavy vehicles, apart from exhaust particles (PM₁₀) which also have a high emission factor in heavy vehicles. But for PM₁₀ the change in emission factor is greater than it is for NO_x. The following general conclusion can be made as regards changes in emissions during the congestion charging trial.

Reduction in traffic by approximately 15 % means most. “Generally speaking” the emissions decrease to the same extent as the traffic. **Reduced traffic congestion lowers the emissions** by a further **1 % point** seen across the entire 24-hour period, and by **2-3 %** at periods of peak traffic. But an increased proportion of heavy traffic and above all **more bus traffic means a relative increase in the emissions, but to a different extent for different substances.** The following digest of the results per substance may be made for the congestion charge zone:

NO_x emissions (nitrogen oxides): Have been reduced by 150 kg per weekday 24-hour period, or by 6.8 %, which is clearly less than the reduction in traffic. The increased proportion of heavy vehicles has a great effect, primarily the additional bus traffic. The reduction can be a maximum of 10 % according to the above.

Exhaust particles PM₁₀: Have been reduced by 6.3 kg per weekday 24-hour period, or by 9.4 %, which is less than the reduction in traffic. The increased proportion of heavy vehicles has a great effect.

CO₂ emissions (carbon dioxide): Have been reduced by approximately 100 tons per weekday 24-hour period, or by 14 %. This reduction corresponds broadly to the reduction in traffic. Carbon monoxide (CO) has been reduced by 1.2 ton per weekday 24-hour period, or by more than 16 %. This is a somewhat larger reduction than the reduction in traffic, and is the result of a small difference in emission factor between light and heavy vehicles.

Non-methane hydrocarbon emissions: Have been reduced by approximately 200 kg per weekday 24-hour period, or by 15.4 %. This reduction is approximately the same as the reduction in traffic. Approximately 65 % of the emissions from passenger cars comes from vaporisation and cold start-ups.

A calculation has also been made for the charge zone of emissions from non-exhaust particles (erosion of the road surface by studded tyres and tyre and brake wear). The basis for the calculations is the estimates of change in traffic mileage within the charge zone made by VTI⁶. This indicates that traffic mileage per weekday 24-hour period has fallen by 310,100 vehicle kilometres ± 91,500 km. According to metering of the Stockholm traffic, the proportion of light vehicles with studded tyres was approximately 70 % during the months January to March. This means a

⁶ Wiklund, 2006

reduction of approximately 40-50 kg PM₁₀ from the road surface in January to March, which corresponds to a reduction of 14 %.

Brake and tyre wear contributes 20-30 mg PM₁₀ per vehicle kilometre with 5 % heavy vehicles and those traffic conditions obtaining within the zone. This means a saving of 6-9 kg per weekday 24-hour period. In total including road surface erosion, a reduction of 45-60 kg per weekday 24-hour period is obtained in PM₁₀ from non-exhaust particles, which corresponds to 14 %. Note that this is far greater than the reduction in exhaust particles of just over 6 kg.

2. Stockholm County outside the charge zone

Traffic mileage in the county is approximately 22 million vehicle kilometres per weekday 24-hour period, approximately 11 times greater than in the zone. Traffic mileage has fallen by approximately 1.5 % taken across the entire 24-hour period, and by 2.7 % in the morning peak traffic hours. Table S2 shows the percentage change for each time period broken down by vehicle type.

Table S2 *Changes in traffic mileage in Stockholm County excluding the charge zone without and with congestion charge. Broken down into time periods and vehicle types.*

County Time period	Difference in %				
	Pass.car	LCV	HGV	Bus	Total
0600-0900	-2.93	-2.70	-2.70	10.28	-2.70
0900-1500	-0.36	-0.12	-0.12	13.20	-0.12
1500-1800	-1.79	-1.56	-1.56	11.57	-1.56
1800-0600	-2.72	-2.49	-2.49	10.51	-2.49
0000-2400	-1.81	-1.58	-1.58	11.54	-1.58

As is evident from the table, traffic mileage for passenger cars has decreased somewhat more than the average decrease, and there has been a certain increase for buses, exactly as in the charge zone. The increased corresponds to approximately 38,000 km for buses in a weekday 24-hour period.

Compared with the charge zone the reduction in traffic congestion is not as evident, which results in the change in emission factors being marginal and in general less than 0.5 %. This means that the reduction in total emissions in general is the same as the changes in traffic, but with a correction for the **greater proportion of buses** (an increase of 0.2 % points). The following compilation of the results can be made for Stockholm County outside the charge zone:

NO_x emissions (nitrogen oxides): Have been reduced by an insignificant degree, by 38 kg per weekday 24-hour period, or by 0.2 %. The greater proportion of buses has a major effect on the reduction being marginal.

Exhaust particles PM₁₀: Have fallen by 1.6 kg per weekday 24-hour period, or by 0.3 %, which corresponds to approximately 20 % of the reduction in traffic. The greater proportion of buses has a major influence.

CO₂ emissions (carbon dioxide): Has fallen by 62 tons per weekday 24-hour period, or by 1.24 %, which is almost equal to the reduction in traffic. Carbon monoxide (CO) has been reduced by 1.3 tons per weekday 24-hour period, or by less than 2.3 %. This is a greater reduction than the reduction in traffic.

Non-methane hydrocarbon emissions: Have been reduced by approximately 170 kg per weekday 24-hour period, or by 1.85 %. This reduction is somewhat greater than the reduction in traffic.

3. Results for five major routes

Calculations of exhaust emissions have been made for the Essingeleden bypass, the Klarastrandsleden bypass, Hornsgatan up to Ringvägen, Valhallavägen and St Eriksgatan. The results are less certain than for the calculations given above, because of uncertain data on traffic mileage with and without the congestion tax and proportions of vehicle categories. In general it can be said that Essingeleden bypass has seen an increase in traffic of 1.1 % but a marked increase in bus traffic. This results in increased emissions of NO_x and PM₁₀ by just under 10 %.

The greatest improvement is to be found on Valhallavägen and St Eriksgatan which both show a reduction in traffic and reduced congestion, which provides marked reductions in exhaust emissions of 10-35 %. Calculations for the Klarastrandleden bypass are unreliable because of dropouts in the flow measurements. But traffic congestion has decreased, which should compensate for the increased traffic mileage for heavy vehicles. On Hornsgatan there is great uncertainty about how the traffic mileage for heavy vehicles has changed.

9. Noise

Traffic noise is a major problem, both in the Stockholm region and in Stockholm's inner city. One way of reducing the noise problem is to reduce the amount of traffic. It was, therefore, natural to ascertain whether the traffic reduction that was one of the aims of the Stockholm Trial would lead to a reduction in the problems of road traffic noise.

The anticipated result was that the trial would not lead to any dramatic improvements in the noise situation. This is because considerable reductions in traffic flow are necessary in order to achieve any improvement. Halving the traffic flow produces a reduction by 3 dBA, which is a scarcely audible change.

The Stockholm Trial provides large amounts of traffic data. There is a large number of stretches of road and points where we know the volume of traffic before the trial, in the spring of 2005, and its volume during the trial, in the spring of 2006. This data has been analysed in such a way that the difference in noise emissions between the two points in time has been ascertained. The details used are traffic flow, i.e. the number of vehicles passing in any 24-hour period, speed, and the proportion of heavy traffic, where these details have been available.

What is more, monitoring data has been analysed from the two fixed monitoring stations operated by the City of Stockholm Environment and Health Administration (*Miljöförvaltningen*). These stations are located on Sveavägen and at Observatorielunden.

The result of the survey is that the traffic noise situation has only been affected to a small extent. In total, results from 152 monitoring sites have been analysed. Of these six show a rise in traffic noise levels of 1–4 dBA. Two of the sites are near the Södra Länken bypass tunnel, four of them are in the inner city. The sites in the inner city follow no evident pattern. In one case another monitoring site nearby shows a small reduction in traffic noise. A reduction in traffic noise by 1–4 dBA was recorded at 18 sites.

Monitoring data from the fixed monitoring stations shows that, for Sveavägen, the noise has diminished by less than 1 dBA, which agrees with the estimates there. At Observatorielunden noise has diminished during the trial by approx. 2 dBA, compared with the same period in the previous year. There is no monitoring site to compare with, as the station is in a park and may be said to reflect the background level and sound from activities in the park.

The level of the changes that have been recorded is relatively modest. It is barely possible to hear a change in sound level of 3 dBA. In order for us to perceive the change as a halving or doubling of the sound level, this has to change by 8-10 dBA.

Reducing the sound level by a few decibels is not enough to solve the problems of traffic noise. The level in excess of acceptable values is considerably greater than this, as is clear from Figure 1 in Chapter 1 .(Not included in this report).

10. Stockholmers' experiences of the urban environment

Background and aims

This work has been carried out with the purpose of following up the interim target of the Stockholm Trial that “the residents should experience an improvement in the environment”. The aim has been to discover how the experience of the urban environment in Stockholm’s inner city has been affected with the introduction of congestion charging and the expansion of public transport.

Realization of the survey

Stockholm County residents’ experiences of the urban environment in Stockholm’s inner city have been studied with the aid of attitude questions, on the one hand before the Stockholm Trial (May-June 2005) and on the other during the ongoing trial (April-May 2006). The work was carried out in the form of a focused group study with hand-picked participants using the same individuals, a total of 660 people, in both 2005 and 2006. A seven-point scale was employed – from “take total exception to” to “agree entirely”.

Percentage response and non-response analysis

The percentage response was 48% in 2005 and 69% in 2006. After both rounds of the enquiry non-response analyses were carried out on a group of a hundred individuals who did not respond to the survey. These individuals had an equivalent socio-economic make-up to the group that did participate in the surveys.

Results and conclusions

Table 1 shows that out of nine factors studied there are three factors in which experiences of the urban environment have improved. These are: car access, good air quality and steady traffic tempo. Two factors show unchanged attitudes: safety and security in the inner city and traffic noise pollution. Four factors have altered for the worse: public transport access, pedestrian access, cycle access and the general opinion that it is pleasant to be in Stockholm’s inner city.

Table 1 *Changes in experience of the urban environment – a comparison of attitudes to experience of the urban environment in the inner city (average points score) and how important these are for a positive experience of being in the inner city*

	2005 average points score	2005 important	2006 average points score	2006 important	Change in average points score 2005-2006
Pedestrian access	6.0	44%	5.8	46%	Worse
Pleasant to be in the inner city	5.9	-	5.6	-	Worse
Public transport access	5.6	46%	5.4	43%	Worse
Feel safe in the inner city	4.7	72%	4.7	72%	Unchanged
Car access	3.7	18%	4.3	15%	Better
Cycle access	4.4	11%	4.1	10%	Worse
Good air quality	3.8	40%	4.1	44%	Better
Traffic noise	3.6	21%	3.6	20%	Unchanged
Traffic tempo	3.4	16%	3.5	15%	Better

Those conclusions that can be drawn about the effects of the Stockholm Trial on the urban environment are:

- In 2006 approximately 80% state that it is pleasant to be in the inner city. Taken overall, this points score is the next to highest of the attitude questions studied. There has, however, been a small deterioration since 2005. Inner city residents have become somewhat more dissatisfied with the inner city/their residential area since 2005, whilst those who live outside the inner city are as satisfied with their residential area as they were in the spring of 2005. It is not possible to assess the extent to which these changes are dependent on the Stockholm Trial or on other factors.
- Of the four most important factors, safety and security, pedestrian access, good air quality and public transport access, air quality shows a clear improvement. The improved air quality can presumably be traced to a reduction in car traffic in the inner city as a result of congestion charging. Safety is unchanged. Public transport access and pedestrian access has deteriorated. The effect on public transport is understandable, as there was a marked influx of passengers, and problems with delays and overcrowding.
- The greater dissatisfaction with pedestrian access might be explicable, for example, by the fact that respondents living in the inner city state that the proportion of cars stopping at pedestrian crossings has dropped between 2005 and 2006. The greater car access may have resulted in fewer cars queuing and drivers can actively choose not to stop as readily at pedestrian crossings in a way that was not possible before the introduction of congestion charging. The deterioration in pedestrian access may be a secondary effect of the Stockholm Trial.
- Half of those people asked have some experience of cycling in the inner city. These individuals experience that there has been a deterioration of cycle access in the inner city. One reason may be that the survey during the congestion charging trial was carried out in April when there was still snow. Responses from the survey have

been compared with the May study from 2005. The experienced deterioration may, therefore, be the result of different weather conditions. Another reason may be that, in those cases where the cyclists share space on the streets, an increase traffic tempo for cars may be thought of as having a negative effect on access for cyclists.

- Car access and the tempo of traffic have both improved as a result of reductions in car traffic in the inner city because of congestion charging.
- The respondents do not experience that there has been any change in traffic noise in the inner city.
- Inner-city children experience that there has been an improvement in the urban environment. The results are, however, based on a rather small number of responses; the attitudes of 70 children (2005) and 35 children (2006) have been analysed.

To sum up, it is difficult to give an unambiguous answer to the question of whether the aim of an improvement in the experience of the environment has been achieved. Some of the improvements as well as some of the deterioration can be explained by the Stockholm Trial. Some changes seem to have other causes – for example weather conditions. As a group, children seemed to have been more satisfied.

11. Sport for children and young people

The aim of this study was to look into the effects of the Stockholm congestion charge trial on sports activities for children and young people. The hypothesis is that, in the short term, the choice of means of transport will change. In the longer term the destination, number of journeys and journey departure time may also change, in that children change their sports club or give up sport.

The results are based on a study of the effects of the congestion charge on sports activity for children and young people within and outside the congestion charge zone. The study comprises interviews with representatives of associations for different sports, administrators and coaches and a case study of five sports clubs. Interviews with largely the same coaches, administrators and team/training groups were conducted both before the trial and during the period of the trial. The evaluation of the effects of the congestion charge on sport for children and young people was made in April 2006. Children's sports activities in the spring term often get going in the second half of January, which means that the measurements were carried out when children and parents had had two months' experience of the trial. Against the background above it has not been possible in this study to draw any conclusions about the long-term impact of the congestion charge on sports activity.

Most children do their sport at a training centre near to their home or school. There are exceptions, e.g. sports with few centres, and elite sport. Better known sports associations and those clubs located in Stockholm's inner city generally have a greater catchment area than smaller associations/clubs. Associations were chosen for the case studies on this basis. Three associations were located within the charge zone and two outside. Those sports selected were riding (few training centres), football (a sport with many players) and basketball (an indoor sport).

In the pilot study in the spring of 2005 a total of 503 interviews were conducted with children/parents from the five teams/groups chosen. In order to acquire wider views from parents of children doing sport a further 18 randomly selected parents were interviewed in the spring of 2005 about their children's travel patterns and how they believed the introduction of the congestion charge would affect these patterns. The following year the aim was to interview the same children in the same training groups as the previous year. In the study in the spring of 2006 one of the groups had split up, one had merged with another group, and one group had divided into two groups. The other two teams remained the same. For the training group which had split up another training group was interviewed, to which many of the children from the fragmented group now belonged. 87 children were interviewed in the spring of 2006, Of the children interviewed in 2005 it is estimated that the majority of these, approx. 45 out of

53 were also interviewed in 2006. In the spring of 2006 interviews were conducted with 9 out of the 18 parents interviewed the previous year.

Distribution of means of transport to the training sessions in the spring of 2006 was as follows: approx. $\frac{1}{3}$ walked/cycled, $\frac{1}{3}$ took public transport, $\frac{1}{3}$ went by car. Returning home after training a larger proportion travelled by car (45%). The proportion going by car to training has dropped in all the teams studied in the case study, and the proportion taking public transport has increased in all teams. The reduction in the proportion of children travelling by car is primarily the result of the children in the study growing older and being able and prepared to travel on their own. In the pilot study in the spring of 2005 approx. one third of the parents responded that they dropped off/collected their children at training because they had nevertheless been using the car earlier that day. One theory is that if, now during the trial, fewer parents are using their cars for other journeys, this should result in fewer children being given lifts by their parents. Part of the reduction in car use to/from training may be a result of the introduction of the congestion charge, but many other factors influencing the choice of means of transport have also changed between the two monitoring dates.

The greatest fall was in car use among children/young people training within the congestion charge zone. Before the trial 44% went by car to their training sessions, and during the trial 12% said that they had gone by car to training. As regards children outside the zone, there has also been a fall in the proportion travelling by car, but the reduction is smaller (from 57% to 41%).

Of the 87 children and 9 parents interviewed about children's travel patterns to and from training in the spring of 2006, it is estimated that a maximum of 4 parents paid the congestion tax when dropping off or collecting their child from training. This means that a total of less than 5% of the parents in this study paid the congestion tax for their journey to fetch and/or drop off their child at training, and have children training at a sports centre located within the congestion charge zone.

Before the congestion charge trial few of the representatives of sports associations, coaches or parents of children doing sport had thought about how the introduction of the congestion charge might affect sporting activities in Stockholm, or their own sport. To the question of whether they had discussed making any changes the general answer was no. From the follow-up interviews conducted in 2006 a consistent picture emerges that the congestion charge has not influenced sporting activity in Stockholm (because the catchment areas for the associations are local, it is difficult to make changes, and most competitions take place at the weekends when there is no charge). None of those administrators interviewed at the sports associations had been asked more than the odd question by coaches or parents about the congestion charge.

Conclusion

A smaller proportion of children travelled by car to and from training sessions during the congestion charge trial than in the previous year. Many other factors have changed at the same time, and it is, therefore, difficult from the interview material to elucidate with any certainty whether the introduction of the congestion charge has contributed to this reduction. Few parents pay the congestion tax for journeys when they are collecting or dropping off their children at sports training.

12. Trade

12.1 Trade and other visitor-intensive business

Introduction

Since the autumn of 2004, the Swedish Research Institute of Trade (HUI) has been assigned the task of evaluating the effects of the Stockholm Trial on the retail trade and other visitor-intensive business in the Stockholm region. The Congestion Charging Secretariat of the City of Stockholm commissioned this evaluation work. HUI presented the secretariat with a preliminary report in the spring of 2005, which is available on the secretariat's website. The current report covers data for the period January 2004 until April 2006 inclusive. HUI intends to present a final report in October 2006, which will cover data for the entire trial period.

Hypothesis

At an early stage in the preparatory work for the Stockholm Trial, the importance was clear of evaluating whether the introduction of congestion charging would affect business development in the region. The retail trade, i.e. sale of products to consumers, in the Stockholm region was regarded as one of the most important business sectors to study in more detail, because the trade is significantly affected by and significantly reacts to changes in economic climate and structural changes in the area. In conjunction with the introduction of congestion charging in London, the retail trade has been one of the sectors discussed most frequently in terms of business sector development. Various survey methods have indicated various results.

It is possible that the Stockholm Trial will have at least two effects on the retail trade. Firstly, the congestion tax may entail a decline in the purchasing power of Stockholm residents in connection with the trial, which is why it is reasonable to speak of an *income effect*. In the absence of congestion tax, it is reasonable to argue that part of this decline in the purchasing power would have benefited the retail trade in the Stockholm region. The size of this income effect depends on, among other things, the amount of congestion tax and the number of passages over the charge cordon at different times, as well as travel patterns in conjunction with shopping trips in general. There are grounds for trying to estimate the amount of this decline in purchasing power, in order to find out the possible significance of the congestion tax to the retail trade in Stockholm's inner city and the whole Stockholm region. HUI does not intend to study this effect in more depth in the present report, but instead plans to return to the issue in the final report.

The second type of effects can reasonably be called *substitution effects*, which means that consumers replace one marketplace with another, depending on the attractiveness of the marketplace or the type of shopping. The retail trade in the inner city, mainly the small-scale retail trade in street-facing shops, has long been losing market share to expanding shop-

ping centres, malls and out-of-town retail parks in the inner city and outlying municipalities. One of the causes of this is the ongoing structural change in the trade, but also the fact that it has been difficult to agree on new locations for retail trade in the inner city. In many cases, property owners and retail trade players have consequently had to make space for new trade within existing areas, or in conjunction with the renovation of other locations in the heart of the city.

In outlying municipalities the retail trade has been allowed to expand and is transformed relatively freely. Old shopping centres and malls have been renovated and extended, while new shopping centres and out-of-town retail parks have been built. This means that consumers living in Stockholm's suburbs have an increasingly reduced need to travel into the inner city to do their shopping. The majority of purchases are made locally instead at a shopping centre or retail park, while the more specialised shops and services of the inner city are used as a complement to other purchases. Consumers who live in the inner city accordingly do the majority of their retail shopping in local shopping centres and malls in the inner city. The expansion of the retail trade in outlying municipalities has contributed to the fact that inner-city residents also travel out of town to buy food, furniture, white goods, home electronics products (brown goods) and other items. The substitution effects have mainly been illustrated by the more rapid growth of the retail trade in outlying municipalities than in the inner city.

The retail trade in Stockholm may also develop positively due to the Stockholm Trial. One of the aims of the trial is to increase accessibility in city traffic. This could lead to greater trade, because accessibility is one of the foremost competitive advantages of the retail trade. HUI has also analysed this using various surveys.

Type of survey

The occurrence of substitution effects is being examined in two ways. One is a retail trade survey that shows the sales trend within and outside the congestion-charge zone cordon. The sales trend has been compiled partly using data from a large number of shopping centres, malls and department stores in the Stockholm region, and partly from VAT statistics issued by SCB (Statistics Sweden), in order to study the development of small-scale retail stores. In the retail trade surveys it should however be noted that a large number of surrounding factors may affect the trade in different ways. These include the national and regional economic climate, rebuilding and new construction of retail facilities in the region, housing construction, people moving into the area, and changes in tourism (domestic and international) as a result of a stronger exchange rate for the Swedish krona.

The second method used to measure possible substitution effects is a consumer survey that HUI has conducted in cooperation with Synovate TEMO. The surveys are cross-section surveys based on interviews with 1,000 randomly selected households in the Stockholm region. The size of the selection and selection criteria enable us to draw conclusions about

larger populations. The survey covers and studies how the inhabitants of different parts of Stockholm County purchased retail goods before the Stockholm Trial started and whether any changes have taken place in conjunction with the trial.

Results

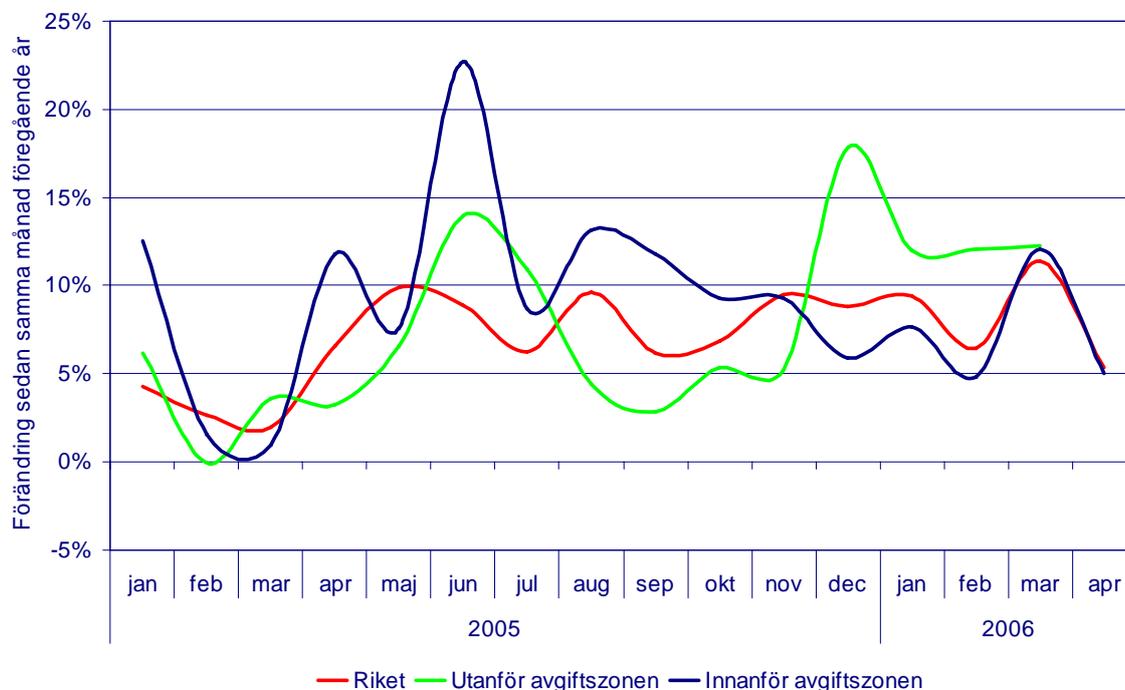
The sales surveys that HUI has performed indicate that the Stockholm Trial has had minor effects on the retail trade in the Stockholm region. The survey of the consumer durables trade in shopping centres, malls and department stores shows that these units have developed at the same pace as the whole of Sweden from January until and including April 2006. The survey of small-scale shops reveals a negative trend during the initial months of the trial. It is too early to say whether this is an effect of the Stockholm Trial; the differences established so far are probably due to changes in trends and seasonal variations such as calendric effects and special events. The retail trade in Stockholm County generated sales of about SEK 95 billion in 2005, of which more than SEK 55 billion was attributable to consumer durables. The retail trade within the congestion-charge zone generates sales of about SEK 15 billion per year. Consumer durables account for 75-80% of total sales.

The consumer durables trade in shopping centres, malls and department stores

Before the trial started there was already a slight upturn in the sales trend for the retail trade in shopping centres, malls and department stores in the Stockholm region as well as in the retail trade in Sweden as a whole. The seasonal variations are particularly prominent in the Stockholm region, but less so in the whole of the country. The variation for Stockholm is largely due to Christmas shopping. The start of 2006 displays the same pattern as previous years, in that the Stockholm region and Sweden as a whole are developing at roughly the same rate.

The consumer durables trade, i.e. home furnishings, home equipment and leisure goods, constitutes a majority of the business in shopping centres, malls and department stores. Figure 1 shows the trend of current prices in per cent for the consumer durables trade.

Figure 6 Trend, in per cent, of the consumer durables trade in shopping centres, malls and department stores in Stockholm's inner city, in a selection of the Stockholm region's shopping centres and malls, and in total retail sales in Sweden, Jan 2005 – Apr 2006.



Source: HUI. The trend in the consumer durables trade outside the charge zone for April will be included in HUI's final report.

/Translation. Figure 1/

Förändring sedan samma månad föregående år = Change since the same month last year

Riket = Whole of Sweden

Utanför avgiftszonen = Outside the congestion-charge zone

Innanför avgiftszonen = Within the congestion-charge zone

The consumer durables trade in shopping centres, malls and department stores within the charge zone has, with the exception of March 2005, displayed stronger growth and larger fluctuations than the consumer durables trade in the country as a whole. Consumer durables within the charge zone showed substantial growth during the first half of 2005, which is partly due to the rebuilding and extension of the Gallerian shopping mall. Growth stagnated during the second half of 2005. This may be due to the launch of several major rebuilding and renovation projects within the charge zone towards the end of 2005, as well as the intensification of competition from shopping centres and retail areas outside the zone during the latter six months of that year. In the first few months of 2006 the consumer durables trade in shopping centres, malls and department stores within the zone has developed at the same pace as the whole of Sweden. The robust growth in March and its stagnation in April are largely attributable to the fact that Easter was in April this year. This has a negative

impact on consumer durables due to additional public holidays when shops are closed.

The consumer durables trade in shopping centres, malls and department stores outside the charge zone grew more slowly than in Sweden as a whole, practically throughout 2005. Consumer durables did display an upward trend during the first half of 2005, but this growth largely followed that of the whole country. It was not until Christmas trading time in 2005 that the consumer durables trade in shopping centres, malls and department stores outside the charge zone grew faster than nationwide. The strong growth continued since then until and including March 2006.

Experiences from London indicate that trade close to the congestion-charge cordon may be affected to a greater extent than retail trade in more central and peripheral locations. One reason given for this is that consumers who live in these areas are most likely to choose a different location in which to do their shopping. HUI has therefore broken down the underlying data on trade in malls and department stores in the inner city and data on this trade in the *malm* districts of Stockholm. Since November 2005 the rate of growth in Stockholm's inner city has been lower than the growth rate in Sweden as a whole, but from the start of March the inner-city growth rate has followed that of the whole country. The sales trend in shopping centres and in the *malm* districts of Stockholm decelerated as from November 2005, and after the New Year, the sales trend has largely followed the national trend.

To summarise, it cannot be proved that the Stockholm Trial has contributed to any difference between the trend in shopping centres, malls and department stores in the inner city and *malm* districts or within and outside the charge cordon.

The consumer durables trade in street-facing shops

One trend in today's retail trade is that large players are growing. Large stores are increasingly expanding and are gaining more and more market share. Today's shopping centres mainly contain chain stores, which have enjoyed very positive growth in recent years. It is therefore relevant to study the development of smaller street-facing shops inside the charge zone since the launch of the Stockholm Trial.

To clarify the development within the zone, HUI has calculated the sales trend in the consumer durables trade for companies with street-facing locations. The consumer durables trade in these locations within the charge zone has experienced a lower growth rate throughout the period than the consumer durables trade in shopping centres, malls, department stores and the country as a whole. Trade in street-facing locations was characterised, like the trade in shopping centres, malls and department stores, by a slight downturn during the second half of 2005. After considerable recovery in January, sales in the consumer durables trade in street-facing locations plummeted again in February.⁷

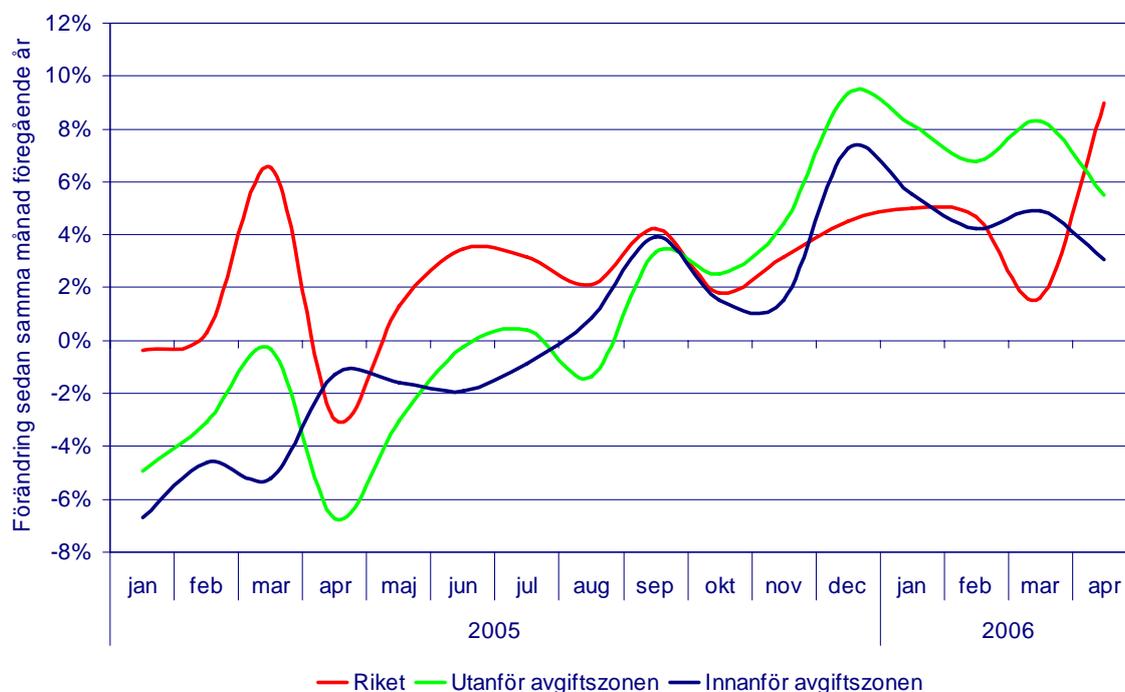
⁷ The rate of growth for trade in street-facing locations in February is based on an excessively limited selection, and the rate will be adjusted.

We could have assumed that the Stockholm Trial had made a negative impact on the retail trade had the latter developed at the same rate or less well than Sweden as a whole since the introduction of congestion charging in January 2006. The rate of retail growth is however decelerating in all series. The drop in sales in the consumer durables trade in street-facing locations must however be seen in the light of seasonal variations and heightened competition both within and outside the charge zone, as well as in the light of the falling sales trend for trade in street-facing locations. This does not eliminate the possibility that sales for individual companies have been negatively affected by the congestion tax. HUI has no opportunity of examining this issue in more detail however, because it would require access to a different type of data from companies within the charge zone.

The non-durables trade

Non-durables shopping, i.e. purchases of mainly groceries but also household chemicals, hygiene products, tobacco, newspapers, magazines and flowers, usually takes place close to home or on people's way home from work. If consumers change their shopping patterns due to the Stockholm Trial, this will probably affect the non-durables trade. Figure 2 shows the trend for the non-durables trade in the Stockholm region from January 2005 to April 2006.

Figure 2 The trend, in per cent, for the non-durables trade in different parts of the Stockholm region and in total retail sales in Sweden from January 2005 to April 2006.



Source: HUI.

/Translation. Figure 2/

Förändring sedan samma månad föregående år = *Change since the same month last year*

Riket = *Whole of Sweden*

Utanför avgiftszonen = *Outside the congestion-charge zone*

Innanför avgiftszonen = *Within the congestion-charge zone*

The non-durables trade for the whole of Sweden shows an accelerating growth rate during the period. The same applies to non-durables both within and outside the charge zone. Since the start of the Stockholm Trial, non-durables have experienced a decline in growth, but this has taken place both outside and within the charge zone. However, the non-durables trade in the whole country developed very strongly during the Easter month of April, while non-durables within and outside the charge zone displayed a poorer rate of growth than nationwide. At the time of writing this report, it cannot be determined whether this is a seasonal effect, the effect of heightened competition from other players not included in HUI's selection, or an effect of the Stockholm Trial.

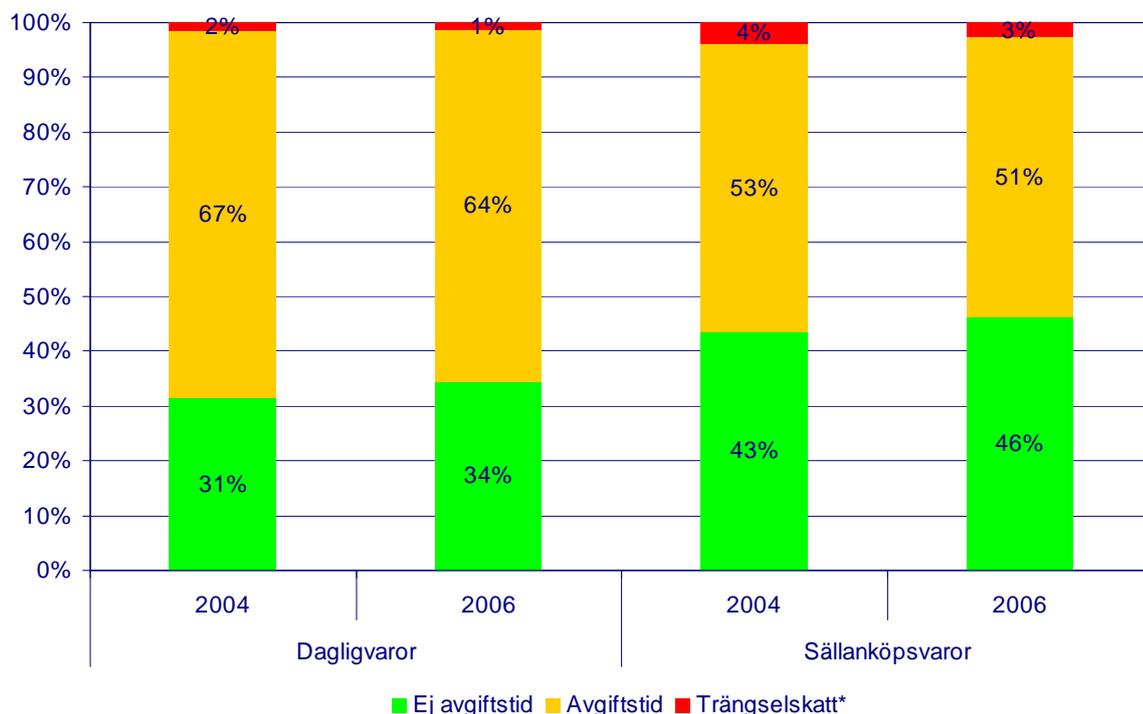
Consumer survey

HUI also commissioned two consumer surveys to supplement the sales statistics and more clearly highlight any substitution effects that the Stockholm Trial may entail. The objective of the surveys was to establish how often and in what way inhabitants of Stockholm did their shopping before the trial and whether their shopping habits have changed during and as a result of the trial. Substitution effects are considered to exist if there are dramatic deviations between the answers of respondents in the survey conducted in November 2004 and the survey from March 2006.

To be affected by the congestion taxes when on a shopping trip, the consumer must travel by car and cross the congestion-charge cordon during a charge period. In previous surveys, HUI has shown that sales during a normal week in most parts of the retail trade are concentrated to the end of the week and mainly after 4 p.m. As we know, no congestion tax is payable at weekends, on public holidays and in the evenings. It is therefore interesting to see whether the shopping trips of Stockholm's residents have changed during the trial.

Figure 3 shows the proportion of consumers who made their latest purchase during the congestion-charge period and the proportion who did their shopping at times when the charge is not payable.

Figure 3 Few pay congestion tax in conjunction with shopping (in percent).



Note: The proportion who make a shopping trip during a charge period, cross the charge cordon and drive a car are affected by the congestion tax.

/Translation. Figure 3/

Dagligvaror = *Non-durables*

Sällanköpsvaror = *Consumer durables*

Ej avgiftstid = *Charge-free period*

Avgiftstid = *Charge period*

Trängselskatt* = *Congestion tax**

In 2004 a total of 31% of the respondents made their latest purchase of non-durables outside the charge period. The proportion who made purchases during the charge period amounted to 69%. Of this 69%, only two percentage points would have actually been affected by the congestion tax. In other words, 2% crossed the *charge cordon* by car during the *charge period*, i.e. on a weekday between 6.30 a.m. and 6.29 p.m. during their latest shopping trip for non-durables in 2004. The equivalent proportion for 2006 was 1%.

This means that shopping habits have not changed notably during the Stockholm Trial. Just like in the 2004 survey, few people travelled by car and crossed the charge cordon during the charge period when making their latest purchases (the red part of the column). This is probably due to consumers buying non-durables close to home and in the evenings, thereby avoiding the congestion tax.

A change that has taken place since the survey in 2004 is that residents within the charge zone shop for non-durables at weekends slightly more often. This may be due to the fact that more companies, department stores and shopping centres have increasingly longer opening hours in the evenings and at weekends, but it nevertheless illustrates a change in the shopping patterns of the respondents. The main decline in visitors appears to have occurred on Fridays since congestion charging was introduced. We cannot see any tendency that consumers who shop on weekdays have chosen to do their shopping after the charge period, i.e. after 6.30 p.m.

The shopping patterns of consumers in terms of shopping for durables appear virtually unchanged in both surveys. A larger proportion of consumer durables are purchased in charge-free periods compared to non-durables; more than 40% of respondents shop at times when no congestion tax is payable. In the 2006 survey, 3% were affected by the congestion tax.

Two possible effects of the Stockholm Trial are therefore that it has become less common to cross the charge cordon and/or that it has become less common to travel by car on these shopping trips. However, shopping trips over the charge cordon cannot be regarded as less common; about a quarter (depending on type of product and where people live) of shopping trips still cross the cordon. Neither have shopping trips by car become less common.

Conclusions

- The effects of the Stockholm Trial on the retail trade in the Stockholm region are minor. This is illustrated in both of the sales surveys that HUI has conducted in shopping centres, malls and department stores within and outside the charge cordon, as well as in the consumer survey that HUI commissioned. The differences that we have been able to establish so far are probably due to trend-related changes and seasonal variations, such as calendric effects and special events.
- The consumer durables trade in shopping centres, malls and department stores within the charge cordon increased by more than 7% during the period January-April 2006, compared to the same period in 2005. This largely followed the trend in Sweden as a whole.
- The analysis of small-scale shops in street-facing locations indicates that sales in these units fell by more than 6% during the first few months of the Stockholm Trial. It is still too early to say whether this is an effect of the Stockholm Trial; the variations established so far are probably due to changes in trends and seasonal variations such as calendric effects and special events. The rate of development for these units is based on preliminary data, which must be interpreted with great caution. The figure may be revised at a later date.
- The non-durables trade within the charge cordon increased by more than 4% during the period January-April 2006, compared to the same period in 2005. This is somewhat lower than the whole

of Sweden, which is probably due to increased consumption in large stores outside the charge cordon. However, this is an ongoing trend throughout Sweden, and it is therefore difficult to see whether it is a result of the Stockholm Trial.

- Trade in the inner city is only dependent to a limited extent on customers who travel by car, and consumers often use other modes of transport for their shopping trips during the charge period to and from the inner city. This was also the case before the trial.
- The Stockholm Trial does not appear to have had any direct effects on Stockholm's tourist trade.
- The Stockholm Trial may have contributed to the fact that slightly more people choose to do their shopping at weekends.

Summary

The sales surveys that HUI has performed indicate that the Stockholm Trial has had minor effects on the retail trade in the Stockholm region. During the period January-April 2006, the passages over the congestion-charge zone cordon fell by about 22%. During this period, the consumer durables trade in shopping centres and malls in the inner city rose by more than 7%, and non-durables within the charge cordon rose by more than 4%. These figures follow those for the country as a whole. The preliminary analysis of small-scale shops in street-facing locations indicates that sales in these units fell by more than 6% during the first few months of the Stockholm Trial. It is still too early to say whether this is an effect of the Stockholm Trial; the differences established so far are probably due to changes in trends and seasonal variations, such as calendric effects and special events. The rate of development for small-scale shops is however based on preliminary data, which must be interpreted with great caution. The figure may be revised at a later date.

The analysis of the tourist industry cannot establish that the Stockholm Trial has had any direct effects on Stockholm's tourist industry or that tourism developed more weakly or more strongly during the initial months of the trial. It is important to follow the development of the tourist industry, because the industry can affect other industries, such as the retail trade.

An important reason why we see no or very few effects on the retail trade is that the shopping habits of consumers have not changed notably in recent years. Before the start of the Stockholm Trial, there was a sense of worry that consumers would change their shopping habits due to the congestion tax. Since the trial started, the inhabitants of the Stockholm region do not appear to have reduced their shopping, neither outside nor within the charge zone. The consumer surveys show that the very small substitution effects that can be established primarily apply to inner-city residents' purchases of non-durables. This type of shopping is now done somewhat more often within the charge zone. The effect is however very minor and does not make an impact in the sales surveys that HUI has conducted. The consumer surveys also show that consumers have started shopping to a somewhat greater extent at weekends, when congestion tax is not payable. However, it cannot be established whether this is an effect of the trial. In addition, the monitoring done by the City of Stockholm Traffic Office has not indicated an increase in traffic at weekends.

Final report on trade

In October HUI presented an additional report, the final report, on the effects of the Stockholm Trial on the retail trade in the Stockholm region. The report is available at: www.stockholmsforsoket.se. The final report differs from the preliminary final report published in June, which has been described above and which formed the basis of the opinions expressed by the expert group, in that data on the development of the retail trade is presented for the entire trial from January to July 2006 inclusive. This new report also contains more reliable data on shops in street-facing locations.

The main results:

1. During the Stockholm Trial the retail trade increased by 6.9 per cent within the zone, which should be compared to an equivalent rise in the trade outside the zone and in the whole country, where the increase totalled 8.1 and 7.7 per cent respectively.
2. The consumer durables trade in department stores and shopping malls within the congestion-charge zone rose by 7.5 per cent, while the consumer durables trade in shopping centres outside the zone increased by 8.2 per cent. The consumer durables trade for the whole of Sweden increased by 8.6 per cent in the same period.
3. The growth of the consumer durables trade in street-facing shops climbed 7.0 per cent during the trial.
4. Sales of non-durables within the charge zone increased by 6.3 per cent. Outside the zone and nationwide non-durables rose by 8.8 and 6.6 per cent respectively.

The differences between the growth rate of the inner-city retail trade and the retail trade in outlying areas is principally due to special events such as the creation of new retail areas outside the zone and renovation and rebuilds of department stores and malls inside the zone. Trend-related changes in the retail trade also had an impact.

HUI's theory was that if the Stockholm Trial had any effect on the retail trade in the Stockholm region, this would be reflected by the economic situation in the region's retail trade deviating from the economic situation in the national retail trade in conjunction with the start of the Stockholm Trial. The absence of a break in the trend during the trial period means that this cannot be confirmed. The conclusion from the preliminary final report that the Stockholm Trial had minor effects on the retail trade therefore still applies.

12.2 Tradespeople and driving schools

The aim of this study is to study the effects of the Stockholm Trial on tradespeople and driving schools. The hypothesis is that the congestion tax has both negative and positive effects on tradespeople and driving schools. Reduced traffic as a result of the tax is positive, because this entails shorter travel times for tradespeople and driving schools, but the tax also involves higher costs for these companies. Whether the net effect is negative or positive depends on a number of different factors, such as how much travel time the companies earn, how the companies value their time, whether they can influence when during the day they travel, and whether they can charge their end customers for this higher expense.

The survey is a case study of a number of tradespeople and driving schools. The same companies' operations were measured both before and during the trial period. The survey also includes interviews with representatives of professional organisations for tradespeople and for driving schools.

The conclusion is that the Stockholm Trial has not led to any major changes for tradespeople. The companies state that there is less traffic and they have shorter travel times. Furthermore, half of the companies charge their customers for the congestion tax. The attitude to the congestion tax is still negative, but to a lesser extent than before the trial.

Driving schools' proportion of clean vehicles has increased considerably between the two occasions when monitoring was conducted. The proportion of clean vehicles at driving schools has risen from 6% in 2004 to 50% in 2006. The driving schools have not changed their operations in other respects.

Tradespeople

On average, tradespeople have paid SEK 25 in congestion tax per day and vehicle during the week monitored in 2006. There is a great deal of variation between the companies. Two of the 12 companies interviewed pay the maximum tax of SEK 60 per day for all their vehicles, on all days of the week monitored, and a relatively large number of the companies pay the maximum tax for some of their vehicles on some days per week. Two companies state that they have never paid the maximum tax. The companies located in the inner city paid an average of SEK 34/vehicle and day in congestion tax during the week monitored, while tradespeople located outside the inner city paid SEK 20/vehicle and day. More than half the companies charge customers for the congestion tax, and about one in five tradespeople debit an extra administration fee for the tax.

Tradespeople notice that traffic in the inner city has decreased. On the major routes, such as the Essingeleden bypass, they perceive that traffic is unchanged. Many point out in the interviews that it is easier to find a parking space in the inner city. Others claim the opposite; that it is more difficult in daytime, because fewer inner-city residents use their car to get to

work. On average, tradespeople estimate that their travel time has fallen by about 20%.

Measurements via drivers' logbooks reveal that the average length of journey has not altered, and was about 13 km on both occasions when monitoring work was performed. The average travel time per journey has decreased, from 22 to 19 minutes. Average speed has increased by 18% (from 33 km/h to 39 km/h).

During the trial, tradespeople have not made any major changes to their operations, besides invoicing customers for the congestion tax.

Driving schools

In the autumn of 2004, three of the ten driving schools in the survey had at least one clean vehicle in its fleet, and four driving schools planned to purchase such vehicles. By March 2006, five of the seven driving schools that previously lacked clean vehicles had purchased at least one to add to their fleet. Just two of the driving schools had no clean vehicles the second time that data was collected. In March 2006, the driving schools interviewed had a total of 50 registered vehicles, of which 25 were clean vehicles.

The driving school lessons usually take place close to the school. The driving schools have a number of relatively fixed routes that are used during the lessons. The schools have not made major changes to their routes in conjunction with the Stockholm Trial. One driving school located within the congestion-charge zone states that its lessons stay within the zone somewhat more often than before. Two schools situated outside the zone say that they stay outside the zone in their lessons more often than before the trial. During the week monitored in 2006, the proportion of lessons that cross the congestion-charge zone cordon was the same as in the week monitored in 2004. The clean vehicles of the driving schools are used more often in lessons where the pupil crosses the cordon compared to the schools' other vehicles.

During the week monitored, the maximum congestion tax was payable for more than 40% of the vehicles (not clean vehicles) on all days. On average, the cost of the congestion tax was SEK 14 per lesson (clean vehicles are excluded). None of the driving schools interviewed charge an extra fee for the congestion tax. Just under half of the driving schools raised their lesson prices at the end of 2005/start of 2006. This increase was partly to cover the extra cost of the congestion tax.

12.3 Distribution/rubbish hauling

This report describes the effects of the Stockholm Trial on distribution and rubbish hauling in Stockholm County. The analysis is based on surveys of how the companies plan their routes, choice of roads and transport times, as well as how many packages they transport, etc. Surveys have taken place both before and after the introduction of congestion charging. In addition, interviews have been conducted with professional drivers and company managers at several companies about their and their companies' perceptions of the trial.

Effects on distribution traffic

The conclusions that we can draw about the effects of the Stockholm Trial on distribution traffic above all apply to three areas: changed speeds on approach roads, choice of roads and the time when the transport is performed.

- The results of the surveys show that speeds of distribution transports have slowed on certain approach roads, such as by the Tranebergsbron bridge and on the Essingeleden bypass. The interviews conducted with drivers point to the same result; they perceive that there is more traffic on Essingeleden and Tranebergsbron now than before the trial.
- The speeds of distribution transports have increased on other approach roads during the trial, especially at Kista-Norrtull.
- The drivers have chosen other routes to some extent to reach their delivery destinations.
- For the transports that go via Essingeleden and Tranebergsbron in the mornings, starting times have been adapted to avoid congestion.
- Distribution vehicles have gained better access in the inner city. Above all, access is faster in the middle of the day (between 10 a.m. and 1.30 p.m.). This has resulted in a shift in the spread of deliveries throughout the day. More deliveries are performed in the middle of the day and fewer are performed in the afternoon. Several professional drivers also mentioned in the interviews that the major reduction in inner-city traffic is particularly noticeable in the middle of the day (see Figure 1). The Stockholm Trial has therefore created scope for performing more distribution transport assignments in one day.
- An assumption made prior to the Stockholm Trial was that the number of goods deliveries could be affected by the trial. This has not however been confirmed in the survey. There are just as many deliveries to the inner city, and somewhat more to the outer parts of the city compared to before the trial. However, it now takes less time to deliver the goods. The drivers manage about five deliveries per hour as opposed to about four during the spring of 2005.

- The distribution companies are positive to the traffic-relief effects that congestion charging has helped to create, particularly at the start of the trial (January to March). But they are predominantly negative to the Stockholm Trial as a whole due to the administrative problems that the trial has caused.
- The speed reduction to 30 km/h (30 km/h zones in the inner city) is not perceived to have affected distribution traffic. Both surveys and interviews show that distribution traffic rarely reaches speeds of 30 km/h in the inner city, regardless of speed limits.

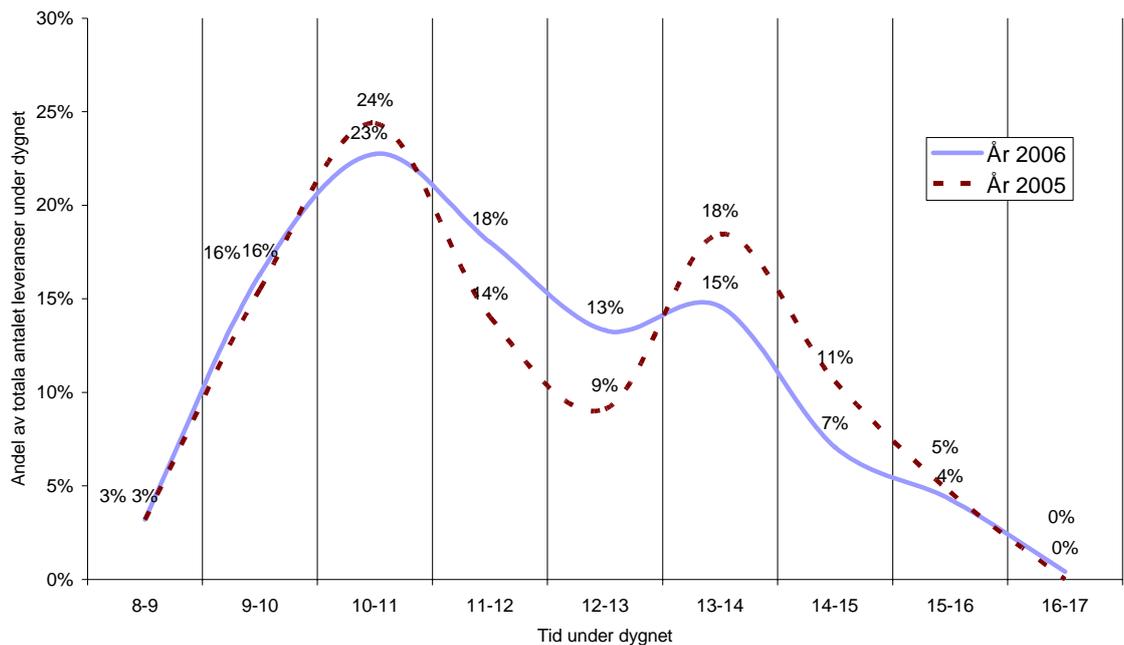


Figure 7: Goods deliveries in the inner city, the spread during the day. Source: the processing of collected data.

/Translation. Figure 1/

Vertical: Proportion of total number of deliveries during the day

Horizontal: Time during the day

År = Year

Effects on rubbish hauling

The following conclusions can be drawn about the effects of the Stockholm Trial on rubbish hauling.

- The assignments have not been noticeably affected by congestion charging. This is partly due to the companies operating to some extent at times during the day when the congestion tax is not payable. It is also due to the nature of the contracts that the companies have with their customers; these contracts are such that volumes, etc are not affected by the congestion tax.
- Transports that go via the Essingeleden bypass take longer.

- Routes have not been re-planned as a result of the trial.
- The problem of cars parking in loading zones is just as extensive as before.

Both distribution and rubbish haulage firms state that it is somewhat difficult to distinguish effects of the Stockholm Trial from effects of the ongoing economic boom. Another general perception is that the administration of the congestion tax has been complicated.

12.4 Taxis, courier services and special transportation services for the elderly and people with disabilities

Introduction

As part of the work to evaluate the effects of the Stockholm Trial, the Congestion Charging Secretariat of the City of Stockholm has commissioned Transek AB to survey how congestion charging has affected taxis, courier services and transportation services for the elderly and people with disabilities in Stockholm County.

Taxis and the special transportation services mentioned above have been exempt from the congestion tax, while courier companies have been obliged to pay.

The aim of this study is to identify the effects of the Stockholm Trial on taxi services, courier services and these special transportation services in Stockholm County. The effects have been identified through analysis of data collected and interviews with drivers and company managements.

The analysis has been based on the following assumptions:

- Greater access in the inner city and on the approach roads entails a boost in productivity and profit for taxis.
- Greater access in the inner city entails a boost in productivity and may entail higher profits for courier transport.
- Greater access in the inner city entails faster transportation using services for the elderly and people with disabilities.
- Increased or reduced access for different types of vehicles may entail a redistribution of courier transport assignments between, for example, cars or vans and bicycles.
- The differences in the obligation to pay the congestion tax between taxis and courier companies affect competition and may lead to an increase in the demand for courier deliveries by taxi.

By greater access we here mean how quickly we can transport ourselves or deliveries to the destination using a taxi, courier vehicle or vehicle used in special transportation services for the elderly or people with disabilities.

Results

The results show that:

- Access has increased in the inner city and on the approach roads during the majority of the Stockholm Trial. According to data from the taxi company Taxi Stockholm, average speed has increased by 3% for journeys that start in the inner city.
- All transport services studied perceive an improvement in their work environment due to reduced congestion (stress).

- Taxis have been able to drive more efficiently, which leads to greater productivity. Measured as the proportion of paid kilometres, productivity has increased from 54% to 60%. Measured as the proportion of paid time, productivity has increased from 39% to 41%.
- Courier companies have been able to drive more efficiently, which leads to greater productivity. Measured in turnover per vehicle and day, productivity has increased for the two courier companies studied; by 10% for one of the firms and 2% for the other.
- Greater access in the inner city has led to faster transportation services for the elderly and people with disabilities. Transport times have fallen by an average of two minutes per journey during the trial. The average speed of these special transportation services has risen by 4%.
- The number of courier assignments performed by cooperating taxi companies has increased between 13% and 16%.
- No redistribution of courier assignments between different vehicle types has taken place as a result of the Stockholm Trial.
- Courier firms are finding the congestion-tax administration a burden.
- The cost of the congestion tax varies between firms, depending on the company type.

A substantial increase in access was perceived at the start of the trial (until and including March). This was followed by a return to increased congestion. In general, the number of taxi journeys has risen compared to the situation before the trial. This is primarily a result of a general upturn in the economy, but also partially due to the Stockholm Trial. The number of courier assignments has also increased, which is mainly attributable to the growth of the economy.

Conclusions:

The Stockholm Trial has led to greater access in the inner city and on the approach roads, particularly during the first few months. This has been followed by some decline, which is partly due to natural seasonal variations in traffic, and partly due to increased volumes of traffic on the Essingeleden bypass that force traffic back to the inner city. An overall conclusion is that the increased access has contributed to greater productivity in the companies and a better work environment for the drivers.

The congestion tax may have affected competition between taxis and courier firms. The analysis shows that we cannot rule out that taxis have gained additional courier assignments at the expense of the courier firms.

The fact that the Stockholm Trial has run over a short period of time has been significant to how the companies studied have adapted their operations and to how customers have adapted their behaviour. For example, the company Taxi Stockholm estimates that it takes time for their customers to change their behaviour (the company has a large proportion of business customers).

Method and monitoring data

The effects on taxis, courier firms and special transportation services for the elderly and disabled have been identified by collecting data for a number of key indicators and through interviews. Data has been gathered so that the trend during the trial period can be compared to the equivalent situation during the year prior to the trial.

During the spring of 2006⁸ interviews were conducted with certain drivers and the managers of the selected organisations. The interviews were conducted to supplement data gathered and to obtain the companies' perceptions of the Stockholm Trial and its effects.

As regards taxis, the company Taxi Stockholm AB has provided data. Data was collected from about 1,500 taxis in Stockholm County for both monitoring periods. The data refers to the following:

- Number of taxis in operation.
- Number of journeys.
- Driving times (divided up into pre-booked and directly ordered journeys).
- Distances driven.
- Proportion of revenue from courier assignments and special transportation services for the elderly and the disabled.

The companies Box Delivery AB and Lillebilsgruppen have provided the following data on courier assignments:

- Number of assignments.
- Distribution of assignments per mode of transport.
- Sales.

Transportation services for the elderly and the disabled have submitted data on journey times and speeds for their assignments.

Data collection has been supplemented with in-depth interviews with drivers and company management. In addition to the firms that cooperated in collection of data, the companies Taxi 020, JetPak, BEST Transport AB and Carrier Transport AB took part in the interviews.

The monitoring period was 21 March-24 April 2005 and 20 March-23 April 2006 (weeks 12-16 of each year). The period was chosen so that the number of working days without public holidays was the same in both monitoring periods.

⁸ From 8 May to 17 May inclusive.

12.5 Journeys to and from two major workplaces

To find out whether journeys to/from work, business trips and deliveries are affected by the Stockholm Trial, a survey of travel habits has been conducted at two large workplaces: the Folksam insurance company and the Swedish Post, Posten. Folksam's office, with 1,355 employees is located at Skanstull in the area where vehicles are subject to congestion tax. Posten's head office, with 1,180 employees is located outside the area where vehicles are subject to the tax. In an Internet questionnaire, the employees answered questions on commuting and business trips. The companies also surveyed incoming deliveries. The survey was conducted during the autumn of 2004 and spring of 2006.

Hypotheses

The employees are affected by the Stockholm Trial in different ways depending on where they live and where they work. The starting point before the survey was that those who cross the congestion-charge zone cordon on their way to and from work are most affected. A total of 84% of the employees at Folksam and 19% of those at Posten cross the charge cordon during their journeys to/from work, irrespective of their mode of transport.

The following was expected for journeys to/from work:

- Fewer journeys to and from work are made by car
- Starting times for car journeys to and from work change
- The travel time for journeys to/from work by car is shorter
- The number of errands run in conjunction with the journey to/from work changes
- More people work via telecommuting/at home

The following was expected for business trips:

- A decrease in the number of business errands
- Fewer business trips by car
- The times for business trips are adapted according to the charge periods

The following was expected for deliveries:

- Fewer deliveries are made to the workplace
- The times for deliveries are adapted according to the charge periods

Results and conclusions

The effects of the Stockholm Trial are most noticeable for people who commute by car over the charge cordon. The proportion of car journeys has fallen for people who commute over the cordon. For those who commute into the congestion tax area (employees at Folksam who live outside this area), the proportion of public transport journeys has also increased more than the proportion of car journeys has decreased. This is due to the

fact that public transport has also gained market share from other modes of transport such as cycling and walking.

For Folksam employees who cross the charge cordon, the proportion of car journeys fell from 29% to 24%. At the same time, the proportion of public transport use increased from 67% to 73%. Of the some 450 car journeys that drivers made each day before the Stockholm Trial, about 75 (16%) fewer journeys were made during the trial. The total number of journeys to and from Folksam for people who cross the charge cordon is roughly 1,930.

The Folksam employees who do not cross the charge cordon increased their proportion of car journeys during the trial. However, the increase is small and marginal in the context.

At Posten those who cross the charge cordon also reduced their proportion of car use. Before the Stockholm Trial 26% travelled to work by car, and during the trial the proportion was 19%. Here drivers make about 20 fewer car journeys per day; a reduction of about 80 to roughly 60 (26%) per day. The total number of journeys to and from Posten for those who cross the charge zone is roughly 370.

The profit that Folksam makes from its reduced need for parking amounts to about 35 parking spaces. At Posten this profit amounts to just a few parking spaces; mainly because so few employees cross the charge cordon. Naturally, the companies only profit where they supply parking spaces for their employees.

Starting times for car journeys have changed. Those crossing the charge cordon adapted their car use to the congestion tax by travelling to a greater extent during times when low or no congestion tax is payable. Motorists who do not cross the charge cordon travelled more during high congestion-tax periods, i.e. at times when there was previously a lot of congestion. This is probably due to the fact that there is now less build up of traffic. Previously, people took greater account of the congestion situation when travelling to and from work. This is no longer necessary, because the congestion has been reduced.

Less travel time for car commuters. During the trial, a larger proportion of car journeys that were made by Folksam employees and that crossed the charge cordon were shorter than 15 minutes. Posten employees made more car journeys home from work that crossed the cordon and were shorter than 30 minutes.

There were no substantial differences in coordination of journeys to/from work with other errands, apart from fewer journeys home from Folksam being combined with shopping.

Telecommuting at both companies does not seem to have been affected by the Stockholm Trial. See the compilation in Table 1.

Table 1 Compilation of results for journeys to/from work

	Folksam, crossing charge cordon	Folksam, not crossing charge cordon	Posten, crossing charge cordon	Posten, not crossing charge cordon
Mode of transport	Fewer car journeys (from 450 to 375 per day). More public transport journeys	More people have made car journeys as drivers or passengers	Fewer car journeys (from 80 to 60 per day), but no increase in public transport proportion. Larger proportion of pedestrians	No difference
Starting time	Larger proportion of car journeys before 6.30 a.m.	Larger proportion of car journeys after 7 a.m. Larger proportion of car journeys home after 3.29 p.m.	Larger proportion of car journeys home before 3.30 p.m.	Larger proportion of car journeys home before 6.30 p.m.
Travel time	Larger proportion of car journeys shorter than 15 minutes	No significant difference	Larger proportion of car journeys home that are shorter than 30 minutes	No significant difference
Errands	The proportion of shopping errands on people's way home has fallen	No difference		
Telecommuting	No significant difference			

Business trips at and deliveries to both companies have not changed in any way that can be linked to the Stockholm Trial. The staff at these workplaces also confirm the impression that business trips and deliveries have been unaffected by the Stockholm Trial.

13. The region's economy

The effect of the Stockholm Trial on the region's economy has been analysed in three subprojects:

- (1) effects on the gross regional product, incomes, costs and prices
- (2) effects on the attractiveness of various areas in the region
- (3) effects on the location of residential premises and places of work.

The results of the three subprojects show that the trial has had the expected consequences on the region's economy. However, these are very small compared with the impact of other underlying factors behind the region's economic development.

Effects on the regional economy

The purpose of the first subproject was to study the effect of congestion charging on the economy of the region as a whole. Previous experience, including that from London, indicates that the impact of congestion charging on regional economies is negligible in comparison with other factors. The subproject used a number of calculations to highlight the extent of the effects that the Stockholm Trial had on the region's economy.

In principle, a congestion tax has repercussions on many areas of the economic system. Three types of effect are examined in the project.

1. The effect on production and employment of the state's expenditure for procuring and administering the system

This kind of state expenditure creates a demand for goods and services, and thus has an impact on production, income generation and employment in the county. The state is responsible for all expenses connected with the system. With reservations for any shortcomings in the statistical material that provides the basis for these figures, the following conclusions may be drawn about the effects of this expenditure on the regional economy.

- Of the total expenditure of approximately SEK 4 billion for the Stockholm Trial, just under half will be a leakage from the Stockholm region and lead to increased demand in other regions.
- This leaves approximately SEK 2 billion relating production in the Stockholm region. This amount is divided more or less evenly between 2005 and 2006.
- The total production of goods and services in the county (the gross regional product) amounted to an estimated SEK 750 billion in 2005. Compared with this, the contribution made by the Stockholm Trial (SEK 1 billion) is minimal.

2. The effect of the congestion tax on business costs and prices

In principle, the congestion tax has two opposite and opposing effects on companies' transport costs.

On the one hand, a congestion tax leads to increased costs for transportation in purely financial terms. The total increase in this respect is equal to the actual amount that companies pay in congestion tax.

On the other hand, a congestion tax is expected to lead to a reduction in traffic, which means that certain types of transport will be quicker. A reduction in congestion also means improved punctuality, and loading and unloading goods in the inner city area may become easier as well. Taken as a whole, therefore, this means an improvement in the productivity of transport.

In other words, congestion taxes have both positive and negative effects on the costs for business and commerce. These changes in costs can, in turn, affect price levels in the county.

Even if there are no comprehensive statistics relating to transport costs, analyses of cost data suggest that the overall effect of the congestion tax on the level of costs and prices in the county is very small:

- In most instances, the congestion tax has only a marginal effect on companies' overall costs for transportation.
- As a rule, transport costs constitute a very small proportion of the final price of goods (and services). If these costs are reflected in the prices, the effect on the general level of prices will therefore be negligible. The cost to companies of congestion taxes over a 12-month period corresponds to less than 0.5 ‰ (one half of one per mille) of the value of the total production of goods and services in the region.
- The effect that improved accessibility has on the productivity of transport varies considerably from industry to industry and company to company. For that reason, it is not practically feasible to calculate the overall effect. By all accounts, however, the net effect of the expenditure on congestion tax and the gains in productivity will be very small.

3. The effect of the congestion tax on consumer purchasing power

Household expenditure for car travel increases for drivers who pass in and out of the congestion-charge zone. Unless these drivers reduce the amount of money they save, congestion charging will lead to reduced private consumption. However, the effect will be the opposite for many of the commuters who previously used to drive to work and who have now switched to public transport. Commuting costs will be reduced for these people, which may lead to an increase in their consumption of other goods and services (apart from transport services). It is therefore correct to say that a

congestion tax has an impact on household purchasing power and thus may affect private consumption as a whole in the county.

During a 12-month period households may be expected to pay an aggregate of approximately SEK 400 million in congestion taxes. This sum should, however, be compared with the total disposable income in the county. Calculations based on official statistics and forecasts suggest that disposable income in Stockholm County during the current year should total approximately SEK 340 billion. This means that the congestion tax would account for approximately 1‰ (one per mille) of the aggregate of all households' disposable income in Stockholm County if the trial had continued for a full year. In plain language, therefore, the tax would not have a significant effect on purchasing power in the county. There is therefore no reason to assume that the tax would affect private consumption in the county.

It should be emphasised, however, that all comparisons have been made with the regional economy as a whole (in other words, in this particular instance, the total disposable income in the county). The situation may vary for individual households. This becomes apparent in the light of statistics relating to different types of households' average income and expenditure. For example, in the case of a household that consists of a single parent with children, paying the congestion tax can have significant consequences for the family budget.

Effects on the attractiveness of various areas

Purpose and hypothesis

Different areas in the region have a greater or lesser appeal. This subproject is based on the idea that differences in the attractiveness of certain areas are reflected in the prices of housing.

The introduction of a congestion tax can affect the appeal of an area in two ways: accessibility and traffic volume. In this sense, "accessibility" is measured as the proportion of places of work in the county that can be reached within a given time and at a given price. In these terms, the extra cost incurred by a congestion tax translates into reduced accessibility for many people in the region, despite the improvement in the flow of traffic within the charge zone. Reduced accessibility leads, in turn, to a reduction in the appeal of certain areas. However, the amount of traffic in a particular area influences an area's appeal in another way, in the form of the level of vehicles emissions and noise.

The purpose of this subproject is to calculate the extent to which the attractiveness of an area would be affected, if congestion charging were to be made part of a permanent traffic solution. In the first instance, therefore, we are looking at the longer term consequences. However, we have also examined whether there are any signs that the appeal of an area has already begun to be affected by congestion charging during the trial period. Both in the short term and in the longer perspective, the prices of residential accommodation will provide an indicator of how attractive an area is.

Method

In order to be able to make our calculations, we have developed a statistical model that describes how dependent property prices are on a number of factors. These determinants include, of course, certain characteristics relating to the premises themselves, such as size and annual fees. They also include characteristics of the area in which the property is located, such as the proportion of residents dependent on social security benefits. These local characteristics also include accessibility and the amount of traffic in the area.

The statistical analysis shows a clear correlation between property prices and local characteristics relating to traffic volumes and accessibility. Consequently, any changes in accessibility and traffic volumes may be expected to affect property prices. However, these effects are relatively small. For this reason, it seems reasonable to assume that the congestion tax has only limited impact on the appeal of an area.

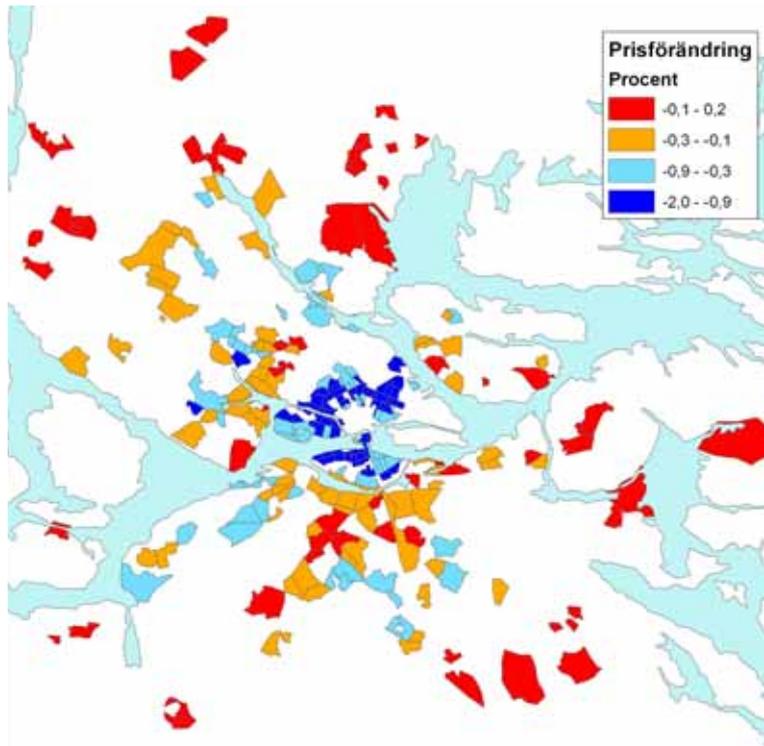
The statistical model has been used to calculate property prices in various areas, both *with* congestion charging and *without*. The difference between these two calculations constitutes the estimated effect of the congestion tax on housing prices in the different areas.

Results and conclusions

The estimated median change in housing prices, as a result of congestion charging is SEK -55 per square metre. (Median = the *middle calculation* of all calculated price changes.) To get an idea of the magnitude of this effect on prices, we can compare other variations in prices over time. The average square-metre price has varied by approximately SEK 50 per quarter over recent years. The annual mean variation is estimated to be approximately SEK 100. Between the third and fourth quarter of 2005 alone, the variation is estimated to be SEK 87. The conclusion, therefore, is that the estimated effect on prices of making congestion charging part of a permanent traffic solution would be roughly the same as the variation in the square-metre price of housing from one quarter to the next.

Calculations suggest that the change in price as a result of the congestion tax varies between the different areas concerned by -2.0% and +0.2%. The median is -0.3%. The changes for each area are illustrated in the figure below.

According to the calculations, approximately 95% of the areas become less attractive (expressed in the form of falling prices) as a consequence of the congestion tax. The main explanation for this is the general deterioration in accessibility. Changes in traffic volume play a less important role. Areas which are predicted to become less attractive than the median are found mainly in the inner city area (within the charge zone), but also in some locations just outside the inner city. Areas which are predicted to become more attractive than the median are found first and foremost in the periphery. The exception is areas in the most outlying municipalities (Järfälla, Salem, Värmdö, Haninge, Upplands-Väsby, Tyresö and Ekerö): according to the calculation model, accessibility has no effect on housing prices in these areas. The effects for these areas as shown in the map are, therefore, a direct result of changes in traffic volumes.



Estimated change in price per square metre, expressed in percent.

We have also studied the prices of condominiums (apartments in tenant-owned housing associations) during February 2006, to see whether the Stockholm Trial has begun to have any effect on these during the trial period. As expected, the analysis does not yet show any signs of the emergence of a geographical pattern corresponding to that of the model.

The calculations lead first and foremost to two conclusions. As expected, the congestion charge does have an effect on the appeal of certain areas. The differences between the areas correspond by and large to differences in accessibility. However, the effects on housing prices are extremely modest compared to the changes that normally occur on the property market. For this reason, it will be factors other than congestion charging that will determine housing price trends in the various parts of the county.

Measurements carried out so far of the actual traffic effects indicate that the values for the deterioration in accessibility on which the model is based are greater than the effect has been in reality. It is therefore likely that the effects on the housing market have also been somewhat overstated.

That the impact of the congestion tax is so limited suggests, among other things, that the anticipated change in the attractiveness of certain areas is unlikely to lead to a general decline in prices: instead it will be other factors that continue to determine the overall price level of housing. What is more interesting in view of the results produced to date is the change in different areas in relation to one another. This may be expressed as a change in relative appeal, or the redistribution of attractiveness within the region.

The relative appeal of the inner city area has probably been underestimated in the model as a result of the fact that the measure of accessibility relates only to accessibility to places of work. The model fails to take into account the appeal inherent in a location in proximity to the large range of services, culture, etc. on offer in the inner city area.

Effects on the location of residential premises and places of work

The effect that the Stockholm Trial has on accessibility in the region will, in the long term, also have consequences for where people choose to live and where companies choose to locate. The third project looks at the effects on the location of residential premises and places of work that would arise if congestion taxes were to be made a permanent feature.

Purpose and hypothesis

The congestion tax affects travel costs and, as a result, the accessibility of various areas. Accessibility is one of the most important factors behind the location of accommodation and places of work. The purpose of this study is to examine what effect the Stockholm Trial has on the siting of residential premises and businesses. It is reasonable to assume that the greatest changes in accessibility will arise in areas adjacent to the congestion-charge zone (both inside and outside the cordon), and it is chiefly in these areas that we can expect changes in the pattern of location.

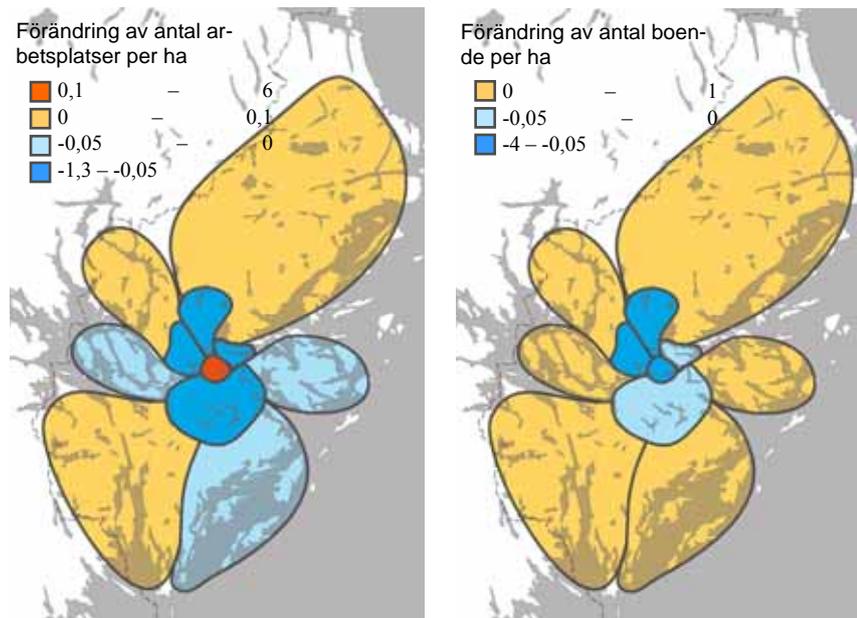
Location effects are long-term. There is therefore no reason to expect any effects during the trial period. It is only when the system has been operational for 20 to 30 years that any clear repercussions can be discerned for the pattern of location. This has consequences for the evaluation method chosen.

Method

The analysis has been carried out with the help of a model that describes how the location of residential areas and places of work in Stockholm County is affected by changes in the transport system. Other factors which can affect the location of these facilities are assumed to be unchanged, and the total number of residents and companies in the region is assumed to remain constant. The driving force behind any change in the pattern of location for the region's inhabitants is the change in accessibility to places of work. By the same token, changes in accessibility also affect workplaces' (companies') access to labour and, as a result, the location of these places of work.

Result and conclusions

By way of summary, the result of the model may be expressed in the following way. Making the Stockholm Trial a permanent feature of a future traffic solution for the capital would mean that the inner city and areas surrounding the inner city would become less attractive for residents, compared with other areas of Stockholm. The areas surrounding the inner city would also lose their appeal as places in which to work, while the inner city would gain in appeal, resulting in a rise in the number of local inner city workplaces per inner city resident. This is illustrated by the following figure, which shows the change per hectare in the number of places of work and residents in different parts of the county.



Schematic summary of changes in the pattern of location of places of work and residents resulting from the Stockholm Trial (based on figures generated by the statistical model for location)

This means that one conclusion of the statistical model's calculations is that the effects of the Stockholm Trial on the location of residential and business properties will, over the long term, be more or less as expected as a result of the change in accessibility. This effect is due chiefly to the congestion tax. The expansion of public transport, which is also an integral part of the Stockholm Trial, plays only a small role in this context.

Another conclusion of the model calculations is that the effects on location are very small. According to the results of the model, the number of residents in the inner city and the areas surrounding the inner city will fall by approximately 1%. The change in the number of places of work will be somewhat greater. In the areas surrounding the inner city, these will fall by almost 3%. However, given that this decrease is projected over a 20–30-year period, this is not a great change. The conclusion is, therefore, that compared with the changes in the numbers of residents and employees that have taken place over an extended period of time, the effects of the Stockholm Trial are likely to be marginal. Nor is there any reason to

believe that congestion charging will have any great effect on the future expansion of residential and commercial areas.

In accordance with the model, the Stockholm Trial generates an effect that runs counter to prevailing trends: pressure on the housing market in the inner city area is increasing, while companies increasingly look to relocate to more modern properties outside the inner city. It is unlikely, however, that the effects of the Stockholm Trial will be sufficiently great to outweigh the underlying factors behind these trends.

In the longer term, it is anticipated that the total number of residents and places of work in the region will increase. Population development scenarios suggest that over a 25-year period the population will increase by 0.5 to 1.0% *per year*. This will also increase the pressure on the central areas of the city. In consequence, any reduction in the appeal of residential properties in the central areas of the city that can be traced to the effects of the Stockholm Trial will not necessarily mean that the actual number of residents in these areas of the region declines. The result is more likely to be a slightly smaller increase than would have been the case without the congestion tax and without the expansion of public transport.

Measurements carried out so far of the actual traffic effects suggest that the model may have overestimated the negative effect of the congestion tax on accessibility. If this discrepancy between the model result and reality were to persist during a prolongation of the Stockholm Trial, this would probably indicate that the negative effects of the congestion tax on accessibility – and, by extension, on individuals' and companies' plans relating to location – are smaller than anticipated.

When interpreting the model results, it should also be borne in mind that the model does not take account of all effects of the Stockholm Trial. The data used to predict changes in location is based solely on changes in accessibility to places of work for residents and changes in accessibility to the labour market for companies. In reality, the location of business premises is also affected by changes in accessibility for goods transport. Attitudes to the location of residential premises are affected by changes in residents' accessibility to service and recreation, and by changes in the urban environment resulting from a reduction in traffic. A more comprehensive model, which also factored these changes into equation, would presumably produce somewhat different end-results, but no such model is currently available. If account was taken of the range of services and of the improved city environment, the inner city area would undoubtedly become more attractive for residents. However, it is not possible with any degree of certainty to pass an opinion on whether the effects would be greater or smaller if all factors were taken into account.

In a city with a congestion-charge zone, the decisive factor with regard to where it becomes more or less attractive to locate companies and housing is the size of the area where the congestion tax applies. If the tax applies only to a very small area, that area will clearly become less attractive, since the number of destinations that can be reached without passing the charging cordon is very limited for people living and/or working within

the charge zone. On the other hand, if the area in which the tax is levied is large enough to include many interesting destinations, it becomes more attractive to be located on the inside of the charge zone.

The size of the congestion-charge zone in the Stockholm Trial is close to the limits that determine whether it is more attractive to be located inside or outside the charge zone.

The model's calculations indicate that it will become more attractive for companies to be located inside the charge zone, while it will be more attractive for residents to live a fair distance outside the charging zone. The areas bordering the charge zone in the Stockholm Trial will become less attractive, for both residents and companies alike.

14. Cost-benefit analysis

A cost-benefit analysis (CBA) is a systematic summary of all the effects and costs of an investment (or similar measure). An analysis such as this is performed in order to endeavour to determine whether an investment is “worth what it costs”: in other words, whether the financial values it creates for society are greater than the financial costs it incurs. To do this, all the effects that the investment may be expected to have on factors such as journey times, traffic safety and emissions are translated into monetary values (in this instance, Swedish kronor, SEK) via so-called socio-economic values that are based on measurements of people’s willingness to pay for shorter journey times, safer traffic, etc. In this way, all the effects – or *benefits* in CBA terminology – can be summarised and compared to the financial outlay, i.e. the cost of the investment. Various alternative investments can also be compared one with the other.

The cost-benefit analysis of the Stockholm Trial is based first and foremost on measurements of traffic volumes and journey times by car, together with passenger statistics from Stockholm Transport (SL). Certain effects, such as those on traffic safety and health, are calculated using models based on the recorded changes in traffic patterns.

The cost-benefit analysis divides the Stockholm Trial into three component parts.

The Stockholm Trial can be divided into three component parts, each of which can be analysed individually from the socio-economic perspective of costs versus benefits. The first component is the congestion-charge system, plus a few minor investments in road infrastructure (primarily in new or improved traffic signals). Congestion charging, however, accounts for by far the greatest proportion of costs and effects.

The second component is the expansion in public transport and the increased number of park-and-ride sites. The expansion in public transport, which accounts for the greatest benefit and cost in this component, comprises expanded bus traffic (new bus routes from the suburbs to the inner city and more frequent departures on inner city trunk routes) as well as more frequent rail departures and more carriages per train. In this study, we have only evaluated the social cost-benefit ratio of the expansion in bus traffic.⁹

The third component is the costs involved in producing and distributing information about the trial and in evaluating the results of the trial.¹⁰ The costs for this cannot be dealt with using conventional, social cost-benefit models, since the values created can not be appraised in purely financial terms.

⁹ This is due to technical difficulties relating to the calculations.

¹⁰ Information directly related to the payment system (i.e. information produced by the Swedish Road Administration about how to pay the congestion tax, etc.), is not included in the costs for the congestion-charge system.

Summation of the estimated effects

The table below shows the estimated annual effects in social cost-benefit terms of congestion charging and increased bus traffic respectively, *excluding* operating and investment costs.¹¹

Table 3: Social cost-benefits, in millions of SEK per year.

(SEK million, per year)	Congestion tax	Increased bus traffic	Total
Shorter journey times	523	157	680
More predictable journey times	78	0	78
Change in mode of travel	-13	24	11
Congestion tax payments	-763	0	-763
Total effect: road-users	-175	181	6
Reduced climate gas emissions	64	0	64
Health and other environmental benefits	22	0	22
Improved traffic safety	125	0	125
Total effect: other factors	211	0	211
Congestion tax revenue	763	0	763
Public transport revenue	184	0	184
Fuel tax revenue	-53	0	-53
Wear and tear on infrastructure	1	0	1
Maintaining public transport standards ¹²	-64	0	-64
Total public sector income and expenses excl. operating and investment costs	831	0	831
Total social cost-benefit surplus excl. operating and investment costs¹³	867	181	1048

Reductions in car and bus journey times worth SEK 770 million per year

The value of shorter and more predictable journey times by car is estimated to be worth approximately SEK 600 million per year. Road-users pay just over SEK 760 million per year in congestion tax (the revenue from congestion tax appears as income for the public sector in the lower half of the calculation). The congestion tax encourages certain road-users to change their travel habits. Some choose not to travel due to the cost; others take advantage of the improvements in traffic flow and access to increase the amount of travelling they do. Overall, this change in travel habits is calculated to generate a loss of SEK 13 million.

The benefits of expanded bus traffic (new direct routes and increased frequency on inner city trunk routes) are estimated at SEK 181 million. SEK 157 million of this figure is accounted for by the benefits of quicker and more convenient journeys for existing users of public transport; the remaining SEK 24 million by shorter journey times by bus for travellers who change to this mode of transport as a result of the congestion tax. (The investment in public transport has not, in itself, had any apparent

¹¹ The figures in all tables are rounded off to the nearest million kronor. This is illusory precision: the figures are not rounded off to make the calculations easier to follow.

¹² The cost for maintaining the same average standard of comfort in public transport despite increased passenger numbers. Calculated using the Swedish Rail Administration's average cost-correlation model (implemented in the SamKalk computational program).

¹³ Not including distortion and opportunity costs (so called tax factors).

effect on the total number of journeys made by public transport.) It has not been possible to calculate the value of other aspects of the investment in public transport (i.e. more frequent departures for all types of rail transport) due to the complex pattern in which these are spread over the day and across the county as a whole. As a result, comparisons of costs and benefits in this study relate solely to the costs for the expansion in bus traffic.

Environmental effects worth SEK 90 per year

The decline in traffic as a consequence of congestion charging is expected to reduce emissions of climate gases from traffic in Stockholm County by 2.7%. This has a beneficial effect to society worth SEK 64 million per year. Other emissions are expected to fall by between 1.4% and 2.8% in the county. The effects on health of these reduced emissions are expected to total approximately 5 life-years saved per year (for Stockholm County as a whole).¹⁴ Together with other environmental effects (pollution and environmental damage), this adds up to a socio-economic value of SEK 22 million per year.

The investment in public transport has not produced any measurable effects on road traffic. Consequently, we have not included the possible effect that the investment in public transport may have had on reductions in vehicle emissions and road accidents. Emissions from the new buses are negligible in this context, even if certain local effects are noticeable.¹⁵

Improved traffic safety estimated at SEK 125 million per year

The reduction in traffic is expected to lead to a 3.6% fall in the number of traffic accidents. The number of people killed and severely injured on the roads is expected to decrease by approximately 15 per year, while the number of people slightly injured is expected to fall by just over 50 per year. The benefit to society of these effects is estimated at SEK 125 million per year.

Public sector income surplus of SEK 830 million, excluding operating and investment costs

The item “Public sector income and expenses” includes increases in ticket revenue for Stockholm Transport (SEK +184 million¹⁶), the cost for maintaining the same average standard of comfort on public transport¹⁷ despite the increase in the number of passengers following the introduction of congestion charging (SEK –64 million), reduced revenues from vehicle fuel tax (SEK –53 million) and reduced wear and tear on the roads (SEK +1 million). Together with the income raised by the congestion tax

¹⁴ Recent research into the impact of traffic emissions on health suggests that the actual effect may be much greater (maybe 50 times as great). Consequently the benefits to society would also be 50 times greater. We have, however, chosen to err on the side of caution by using somewhat older models for calculating the effects on health.

¹⁵ City of Stockholm Environmental and Health Administration (2006).

¹⁶ Based on a rough estimate: Stockholm Transport’s own figures are not yet available.

¹⁷ The aim is to increase the number of seats to keep pace with the number of passengers so that there is no relative increase in the number of standing passengers. The calculation is based on the cost of producing extra seats/kilometre in accordance with the Rail Administration’s key ratio for this.

(estimated to total SEK 763 million), this gives an income surplus of SEK 831 million per year, *excluding* operating and investment costs.

What costs shall these benefits be compared with?

The investment and operating costs with which these surpluses should be compared depends on the perspective to be chosen. A social cost-benefit analysis differs from most other evaluations of the Stockholm Trial in as much as the perspective must be extended into the future for the analysis to be truly meaningful. For that reason, we have chosen to calculate and analyse the effects of the social costs and benefits of the Stockholm Trial using three different timescales, which at the same time represent scenarios for making decisions supported by the CBA.

The Stockholm Trial itself produces a loss in socio-economic terms

If we consider only the costs and benefits that arise during the trial period (i.e. levying the congestion tax from 3 January to 31 July 2006, and expanding public transport from 22 August 2005 to 31 December 2006), the costs do, of course, exceed the value of the benefits. As the results and conclusion for this timescale are obvious in advance, this analysis may appear relatively uninteresting and superfluous. The motive for the Stockholm Trial has never been to achieve traffic-related benefits of such magnitude that these alone would justify the costs for the trial. From a political point of view, the motive behind the Stockholm Trial lies instead in the value of the lessons learned. The politicians clearly hope that it will subsequently prove possible to translate these experiences into permanent measures. Because it is so difficult to put a price-tag on the value of such experience, considerations like these are not included in traditional CBA models. The degree to which these values motivate the costs incurred is therefore a question that the cost-benefit analysis cannot answer.

That the analysis has been included nonetheless, is due to the fact that it represents one distinctly possible outcome of the decision process that lies ahead. This is because the perspective corresponds to what would happen if the Stockholm Trial were terminated and not resumed in any form.

Table 4. Costs and benefits during the Stockholm Trial (in SEK millions during the trial period)¹⁸.

NB. The duration of the trial periods for the congestion tax and the expansion of bus traffic differ.

(SEK millions, during the trial period)	Congestion tax	Increased bus traffic	Total	Increased rail traffic/park-and-ride	Information and evaluation
Surplus of social benefits over costs (excl. operating and investment costs – see Table 3)	506	248	754	(not calculated)	(values n.a.)
Costs during trial excl. residual values	-1821	-582	-2403	-88	-210
Distortion and opportunity costs ¹⁹	-708	-308	-1017	-47	-111
Net social benefit of the Stockholm Trial	-2,023	-642	-2,666	---	---

The calculations suggest that the congestion charging system and the expanded bus traffic have cost society approximately SEK 3.4 billion²⁰ at the same time as the value of the positive effects during the trial period does not exceed around SEK 750 million. The result is a net cost to society of approximately SEK 2.7 billion, most of which is accounted for by the congestion charging system itself. To this should be added the value of and costs for other expansions of public transport, together with costs for information and evaluation measures, and the admittedly difficult-to-estimate values represented by the experiences gained from the trial and the opportunities to put these into practice if the scheme is continued.

Making the trial a permanent feature of a traffic solution would produce a net social benefit

The most relevant perspective as far as Stockholm is concerned is that the trial has actually been carried out and thus indicates the probable socioeconomic effects of making congestion charging a permanent feature of a traffic solution for the capital for an extended period in the future. In view of the fact that the trial has actually been carried out, no account is taken of the investments that have been made during the trial period and which cannot be recouped if the trial should be terminated. As is the case with the first perspective (to consider only the costs and benefits of the trial), this does not present a full picture of the social costs and benefits of the Stockholm Trial, but on the other hand, it does represent what in all likelihood will be the result of the impending decision-making process.

¹⁸ Benefits during the trial period are calculated based on the estimates of annual benefits in Table 1, multiplying the annual benefits of congestion charging by 7/12 and the annual benefits of public transport improvements by 16.5/12.

¹⁹ The distortion cost is the “hidden” social cost of a tax, caused by the phenomenon that the so called tax wedge reduces the efficiency of the exchange of goods and services. The opportunity cost corresponds to the benefit that the resources used could have created if they had been used for another purpose.

²⁰ Of which SEK 2.3 billion is “visible” public expenditure and a further SEK 1 billion is distortion and opportunity costs.

Table 5. Costs and benefits if the Stockholm Trial were to be made permanent.

<i>(SEK millions, per year)</i>	Congestion tax	Increased bus traffic	Total
Surplus of social benefits over costs (excl. operating and investment costs – see Table 3)	867	181	1,048
Operating costs	-220	-341	-561
Distortion and opportunity costs	118	-181	-62
Net annual benefit for society if the Stockholm Trial is made permanent	765	-341	424

The operating cost of a permanent solution based on the congestion charging system is estimated by the Swedish Road Administration to be approximately SEK 220 million per year.²¹ As the system generates a financial surplus, a further item on the plus side is included in the form of reduced distortion and opportunity costs.

From a CBA perspective, the congestion charging system is very profitable, generating a net surplus of approximately SEK 765 million per year after deductions for operating costs.

On the other hand, judged by the same criteria, the expansion of bus traffic is expected to be unprofitable. Operating the buses costs SEK 522 million a year²², while the value of shorter journey times does not exceed SEK 181 million a year.

Benefits exceed costs overall

Another decision perspective includes the cost of writing off investments in the calculation. In a way, this is the most comprehensive analysis as it does not exclude any costs or possible benefits. However, even if this alternative has the indisputable advantage of being comprehensive and complete, it does smack of a theoretical construction: the perspective is not actually relevant to the situation in Stockholm. It is not possible to undo the effects of the trial, or to recoup the cost of the investments made. This perspective is, however, an interesting one, if only to provide guidance for other cities. It is the one that most closely resembles the situation which would have existed if the Stockholm Trial had not yet been carried out, and the planners were instead faced with the decision of possibly implementing the various measures.

²¹ This is the Swedish Road Administration's assessment. It is possible that costs could be reduced further if the existing conditions were relaxed by changes in the law and amendments to system requirements. This is, however, only speculation based on comparisons with similar systems in Norway.

²² Including distortion and opportunity costs: SEK 341 m + SEK 181 m = SEK 522 m.

Table 6. Costs and benefits if the Stockholm Trial were to be made permanent.

<i>(SEK millions, per year)</i>	Congestion tax	Increased bus traffic	Total
Surplus of social benefits over costs (excl. operating and investment costs – see Table 3)	867	181	1048
Operating costs	-220	-177	-397
Distortion and opportunity costs	118	-94	25
Depreciation costs for investments	-50	-3	-53
Distortion and opportunity costs	-26	-2	-28
Net annual benefit for society incl. depreciation on investment costs	690	-95	595

In this model, the investment cost for the congestion charging system is equal to the entire start-up cost: in other words, not only the costs prior to the start of the system, but also the operating costs during the first half of 2006 together with certain other additional minor costs, such as those for traffic signals, and the services of the Swedish Enforcement Agency and the Swedish Tax Agency. This start-up cost also includes, in addition to purely technical investments, system development in a wide sense, educating and training staff, testing, information work, etc. Also included are the Swedish Road Administration's costs for closing down the system and evaluating the results during the second half of 2006. This entire initial cost for the system is budgeted at approximately SEK 2 billion (of which SEK 1,050 million was incurred prior to the start of operations).

Investments in the congestion charging system are depreciated over 40 years, as is customary for traffic related investments.²³ “Operating costs” include all maintenance and reinvestment costs which are required to operate the system in the future, including the necessary updates of technology and hardware, etc.

If the costs for depreciation are included in the calculation, the congestion charging system yields a surplus of benefits over costs amounting to approximately SEK 690 million per year.

Another way of placing the investment cost in relation to this annual surplus is to calculate how long it takes before the investment cost has been “repaid” in the form of benefits to society: in this instance, four years. This is a very quick repayment period, compared with, for example, investments in road infrastructure and public transport, which even under relatively favourable circumstances have a repayment time of between 15 and 25 years. The conclusion that congestion charging is profitable for society even if the investment cost is taken into account is therefore not

²³ From a social cost-benefit perspective the depreciation period is the entire length of time during which the investment may be expected to create benefits for society, given that it is properly maintained and looked after. This should not be confused with the technical lifespan (“service life”) of the investment: the cost for maintenance and re-investment is included under “Operating costs” in the table. Nor should it be confused with the depreciation period used in accounting terms, which is usually considerably shorter – typically 1–5 years.

dependent on the length of time over which it is decided to depreciate the investment. To generate a surplus, the system needs to be operative for no more than four years.

The investments which are necessary to expand the bus traffic are negligible in a long-term perspective. One of the reasons for this is that the cost of purchasing the buses is included under operating costs.

Conclusions from the trial period

If the Stockholm Trial is considered as a short-term trial that is terminated and not subsequently resumed, this will incur a net social cost of approximately SEK 2.7 billion (not including the effects of the expansion of rail traffic and the construction of park-and-ride sites). The majority of this loss derives from the initial investment in and the subsequent operation of the congestion charging system. This perspective is, however, of limited interest. It is not surprising that the investment costs of a congestion charging system cannot be recouped during the trial period. The value of the experiences gained during the trial and the value of a possible future continuation are not included in this calculation.

It is somewhat more surprising, however, to note that the expansion in bus traffic during the trial period is not expected to produce any net social benefit. The costs are estimated to be in the region of SEK 900 million²⁴ while the benefits are not expected to exceed approximately SEK 250 million.

Looking at things from a narrow, Stockholm-based perspective, however, the Stockholm region stands to benefit by SEK 230 million from the trial – provided that the State pays for the trial costs with resources that would otherwise not have benefited Stockholm directly. If, on the other hand, the assumption is made that the costs for the trial are financed by an increase in state (direct) taxation, the Stockholm region makes a loss on the trial. In this scenario, the region pays approximately 45% of the trial costs, which equates to a value considerably greater than that derived from the trial in the form of social benefit.

Conclusions – making the congestion tax a permanent feature

If the congestion tax were to be made a permanent feature, it is estimated that this would generate an annual surplus of social benefits over costs equivalent to approximately SEK 765 million after deductions for operating costs. In other words, making the system permanent would generate considerable values in social benefit.

This means that the investment costs to society of the congestion charging system would be repaid in the form of social benefits within four years. This is a very quick repayment period, compared with, for example, investments in road infrastructure and public transport, which even under relatively favourable circumstances have a repayment time of between 15 and 25 years.

²⁴ SEK 580 million in operating and investment costs and SEK 310 in distortion and opportunity costs.

Another perspective, which does not take social costs and benefits into account, but focuses solely on hard cash, is the purely financial one. In this perspective the investment costs are covered by income from the system in just over 3.5 years. If the system is to operate for 10 years, it will generate a net income of approximately SEK 3.5 billion. If it is operated for 20 years the net income will be almost SEK 9 billion.²⁵

If the focus is narrowed to concentrate solely on the direct effects of congestion charging on road-users, the result is a disbenefit of SEK 175 million per year, as the reduced journey times alone are not deemed to compensate for the increase in travelling costs for the average road-user. It is only when the income from congestion charging is used to benefit residents/road users directly through investments in traffic infrastructure or in other ways, that any net social benefit is created. This means that the way in which the income is used is extremely important when deciding which groups are “winners” and “losers” respectively.

Conclusions – making the expansion of bus traffic a permanent feature

The figures do not suggest that the expansion of bus traffic will be profitable from a socio-economic perspective. The benefits are calculated at SEK 180 million per year, compared with operating costs of SEK 522 million per year (including distortion and opportunity costs). Some caution should be exercised, however, when interpreting this result. It is not unusual for public transport to be unprofitable, but for various reasons, it is still considered important to provide this service. For this reason, it would be advisable to carry out a more in-depth analysis about possibly making the investment in expanded bus traffic a permanent feature.

²⁵ Neither figure takes into account interest rates or traffic growth.

15. Equity effects

This study (Transek 2006:36) is a complement to the report “Economic and Equity Effects of the Stockholm Trial” (Transek 2006:31). The study focuses on the effects a permanent congestion-tax system would have on different groups of citizens.

The analysis focuses on the so called *direct road-user effects* of the congestion tax, or those effects that directly affect the citizens’ travel. These include changes in travel time, costs of paid congestion tax and costs of adaptation (sacrifices in travel due to the congestion tax). Environmental and traffic safety effects are not addressed as there is no research available on the estimated cost-benefit of these effects among different groups.

To present a complete picture of the net effect for citizens, the distribution effects of three hypothetical revenue uses are analysed: equal return to all citizens in the county, reduction of income tax and reduction of public transport fares. How the revenues from an actual system *should* be used is a purely political question and is not addressed in the study. The revenue uses in this study are examples whose purpose is to illustrate what the resulting effects of the choice of revenue uses would be. They are only chosen because they are easy to explain and simple to calculate for cost-benefit effects, and not because they are necessarily realistic or ideal.

A few drivers pay the majority of the congestion taxes – but the majority pays sometime

A large percentage of drivers in the county pay the congestion tax at least now and then. During one two-week period²⁶ of investigation alone, nearly half of all privately owned cars in Stockholm paid their congestion tax at least once. At the same time, only a small number pays a lot of congestion tax; about 4% of the county’s vehicles – which equals 1.2% of the county’s residents – reached a total cost of SEK 200 or more during the investigated fortnight. However this 4% accounted for one-third of all revenues from privately owned vehicles. Seventy-five percent of revenues from privately owned vehicles originated from fewer than 100,000 vehicles, which corresponds to about one-fifth of all cars in Stockholm County or 5% of the county residents²⁷ (if we assume for simplicity’s sake that one person represents every car). The disparity over a year should be slightly less than during a two-week period, but the conclusion is still that a small number of drivers account for a large percentage of the congestion tax payments.

²⁶ The Swedish Road Administration cannot compile statistics for a longer period than this, because data is not allowed to be stored for more than two weeks.

²⁷ A certain percentage of revenue comes from cars outside of Stockholm County.

Variation within the groups is great

The figures above indicate that there is great variation as to how much congestion tax people pay. The study presents the average effects for different groups, but the variation *within* a group is very great. Even within the groups that on average pay very little congestion tax, there are individuals who pay a lot of congestion tax. Likewise, even in the groups that pay a lot of congestion tax, there are many individuals who rarely pay congestion tax.

“Wealthy men in the inner city” pay the most

Looking only at the direct traffic effects – changes in travel time and increases in travel costs – it is estimated that all groups experience a (macro)economic loss (on average). It is only when the revenues are used for the good of the citizens that they gain an economic net profit. Examining the degree of loss for different groups *on average*, the conclusions are that

- Residents of the inner city and Lidingö lose about twice as much as residents in other areas
- Households with greater buying power²⁸ pay nearly three times as much as households with low buying power
- Those who are gainfully employed pay about three times as much congestion tax as others
- Men lose nearly twice as much as women
- Households with children pay more congestion tax; households with two adults pay more congestion tax (per person)

Statistically, one is thus “hardest hit” by the congestion tax if one is a well-to-do, gainfully employed, male living in a household with two adults and children in the inner city or in Lidingö.

Residents of the inner city and Lidingö affected most

Those experiencing the greatest average net loss per person when taking into account the direct traffic effects (travel time, congestion tax and adaptation costs) are the residents of Lidingö and the inner city. (Note that this is not considering benefits of the revenues of the congestion tax.) On average, the loss is estimated at approximately SEK 500 and SEK 450 per person and year, respectively. The loss for other areas is about half as much – with the radical exception being the northern outer suburbs, where the average economic net loss was only 78 *kronor* per person and year.

²⁸ In other words, high income per household member, taking into consideration the age of the members

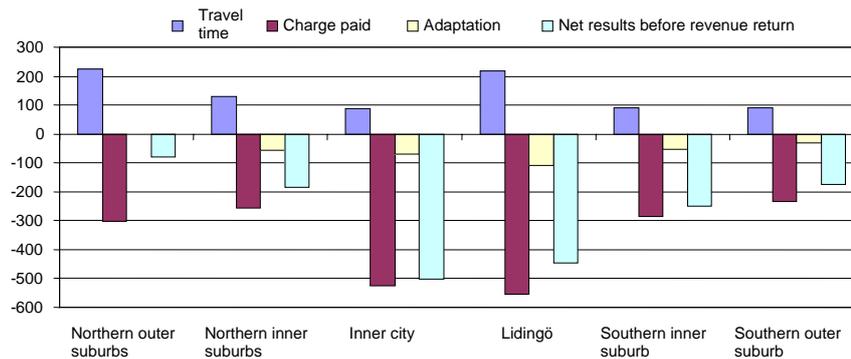


Figure 1: Total traffic effects per housing area (SEK per person and year).

The residents of the central areas have also changed their travel habits the most. The number of congestion-charged car trips to and from the inner city decreased by about 25-30% for the residents of the inner suburbs, Lidingö and inner city. The decrease in the outer suburbs is considerably smaller: about 10%. On average, residents living closer to the city seem to find it easier to reduce their car travel by choosing, for example, other transportation or destinations.

The introduction of congestion taxes meant that car travel costs increased by barely 5% for the residents of the outer suburbs, 11% for the residents of the inner suburbs and 31% for residents of the inner city.

Thus, inner city residents have the smallest amount of travel time reduction despite the fact that they pay almost the most in congestion tax. One reason is that most drivers save travel time in the morning driving into the inner city and in the afternoon driving out of the inner city while those living in the inner city tend to be driving in the opposite direction. According to the cost-benefit estimations, however, inner city residents suffer the greatest net losses due to the congestion tax. Despite this, the inner city residents are the most positive to the tax, according to opinion surveys. It is interesting to note and speculate on why it is that the inner city residents' opinions do not match the predictions. Perhaps this is because those who use their cars only occasionally, "seldom-drivers", place a higher value on their time gain than the average driver, which means the predictions underestimate the value of time gain. This may be because those factors that are hard to measure, such as environmental benefits and increased traffic safety, are underestimated in the calculations. In the estimation above, these factors are missing completely, but the estimated (macro)economic value is so strong in comparison to the travel time gains that the phenomenon remains.

High-income earners affected more than low-income earners

(The following analysis is based on spending capacity, or the estimated income per person in the household after adjustment for the ages of the members of that household. The conclusions do not change if the analysis is instead based on household income only.)

Accordingly, the “wealthier” a household is (meaning those with more spending capacity), the more likely the household is to make congestion-charged trips compared to the average household. This is partly because “wealthy” households use the car more frequently and partly because they are more likely to be found in or near the inner city. Taking all of the effects on road users into account, the average economic net loss (excluding the use of the revenues) varies between SEK 106 for the group with the lowest spending capacity to SEK 405 for the group with the highest spending capacity.

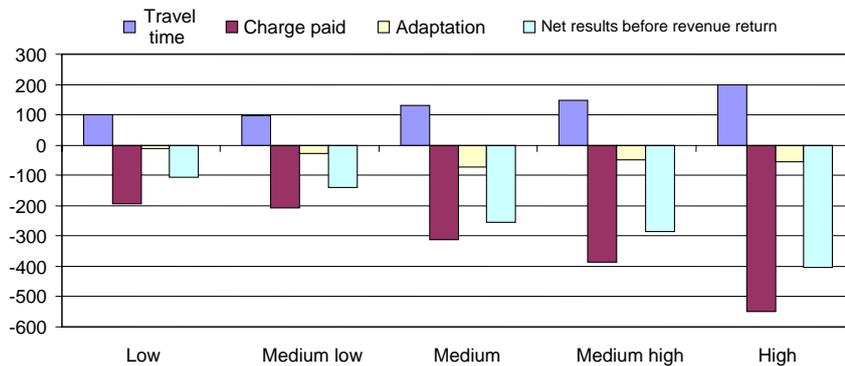


Figure 2: Total traffic effects for households with different spending capacity (SEK per person and year).

The percentage of increased costs also varies according to spending capacity. The introduction of congestion tax means costs for car trips increased 6% for the two groups with the lowest spending capacity, 8% for the group with median spending capacity and 9% and 11% respectively for the two groups with the highest spending capacity.

The crux of the distribution effects of a congestion tax system is however how the revenues are used. The diagram below illustrates three hypothetical uses of revenue: all residents in the county share the revenues equally, the revenues are used to lower taxes and the revenues are used to lower public transport fares.

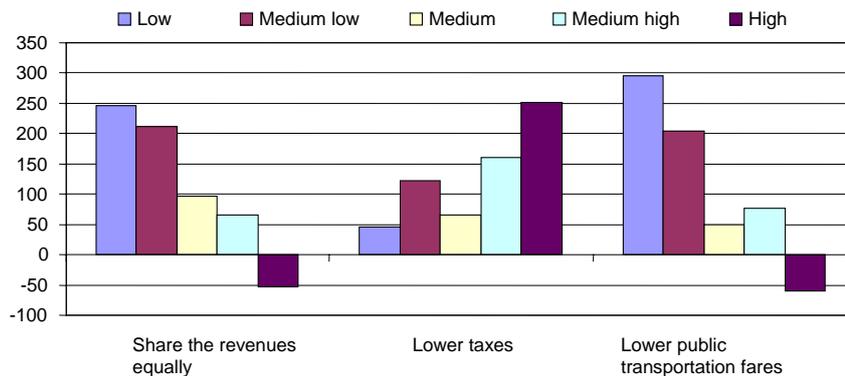


Figure 3. Net effects for households with different spending capacity, for different hypothetical revenue uses (SEK per person and year)

How the revenues are used is key to the cost-benefit effects

The analyses illustrate that the use of revenues is key to the total distribution effects. The difference in the cost-benefit profile among the different

possible revenue uses is often larger than the differences in the cost-benefit profile for the actual congestion charging.

The young and the low-income earners profit if the public transport fares are lowered

If the revenues are used for public transport—as illustrated in our calculation as lowered fares—then the young, the low-income earners, the single, the women and the residents of the inner suburbs all profit from the measure as a whole. These groups pay relatively little in congestion tax (on average) and use public transport to a greater degree than other groups.

The groups that, on average, would be affected adversely if the revenues were used in this manner are for the most part gainfully employed people with children, high-income earners and residents of the inner city and Lidingö. These groups pay a lot of congestion tax and use public transport to a lesser degree than other groups.

High-income earners and residents of suburbs profit if the tax is lowered

If the revenues are used to lower income tax—or if we imagine that the revenues are used to finance something which is otherwise financed with income tax—then the high-income earners, the elderly, the single parents and the residents of the northern suburbs will be the winners. Those adversely affected by such measures are the residents of the inner city and Lidingö.

Commercial traffic and business trips

Private journeys comprise approximately 64%, business trips 20% and commercial traffic 16% of trips across the congestion-charge zone cordon during congestion-charge hours. Commercial and business traffic pay approximately SEK 275 million per year in congestion tax, but make gains in travel time to the value of SEK 370 million per year. Both business travellers and commercial traffic are then “net winners” already *before* they even share in the revenues. The value of the gains in travel time are calculated to be (on average) greater than the congestion tax paid by these groups. Just over 60% of the gains in travel time in the cost-benefits analysis are made by commercial and business traffic despite the fact that these two comprise only about 35% of all the traffic as a whole.

16. Knowledge of and attitudes towards the trial

16.1 Companies

Background

There are approximately 83,000 companies in Stockholm County, of which about 90% are small businesses with fewer than 10 employees.²⁹ Of the small businesses about half are single-person companies with no employees and most consist of so called “work on the side”. The companies covered by this study have at least one employee. About half are small businesses with 1-5 employees, about a third are medium-size companies and about 20% are larger companies with 50 employees or more.

Assignment

How do companies in Stockholm County view the Stockholm Trial and congestion tax, and what is their outlook on the tax’s short-term and long-term effects? To try to answer these questions, an attitude survey was carried out by telephone with people in leadership positions at 300 companies in Stockholm County. The interviews were conducted before the Stockholm Trial, in spring 2005. To see if attitudes to the trial and permanent congestion tax had changed while the trial was in effect, the interviews were repeated in the spring of 2006, while the trial was still going on. On both occasions the main attitude questions were the same.

The study was carried out as a panel, meaning that the same companies participated on both interview occasions.

Main findings

Between the two interview occasions there was a change in attitude towards the Stockholm Trial as a whole. The proportion of companies that were negative fell from about 65% to 45%. The proportion of those who were positive rose from about 20% to approximately 35%. The attitude to a permanent congestion tax changed in the same direction. The proportion of companies that were negative to a permanent congestion tax fell from about 65% to 50%, and the proportion of positive rose from about 20% to approximately 30%.

Conclusion

Even before the Stockholm Trial, the interviewees were relatively well-informed about it. Almost all knew that there would be a charge for passage to and from Stockholm’s inner city. Close to 90% were aware of when the trial would begin and how long it would last. About 60% knew during which hours of the day there would be a charge. Roughly 65% knew that public transport would be extended and about 60% knew that the surplus from the Stockholm Trial would go back to the Stockholm region, primarily to public transport..

²⁹ *Fakta om företagandet i Stockholm 2005 (Facts about Business Management in Stockholm 2005)*. Stockholm Business Region.

The interviewees' experiences of the trial allayed their worst fears, and the positive effects were attained to a greater degree than had been expected before the trial began. During the ongoing trial with the congestion tax (April 2006), however, a majority of the companies were more negatively than positively disposed towards both the Stockholm Trial and a permanent congestion tax. Some still feel concerned about a permanent tax's more long-term effects on e.g. employment, localisation and regional growth.

16.2 Residents of Stockholm County

(USK June 2006) Since the trial period with the congestion tax began, the knowledge of the trial period has increased significantly. This was already noted during the autumn of 2005. Today a little more than eight out of ten think they have enough knowledge about the trial. In the autumn of 2005, six out of ten thought their knowledge was sufficient.

Men still feel they are more familiar with the trial than women do; but relatively speaking, the number of women who feel adequately familiar with the trial has increased more. Compared with other age groups, only those who are under the age of 25 feel less familiar. Still, seven out of ten in this group feel their knowledge of the Stockholm Trial is adequate today.

Motorists and public transport users differ slightly in their knowledge of the trial. Among those who travelled to, from, or through the inner city during the congestion-charge period in the week before the interview, nearly equal numbers of motorists and public transport users felt they had enough knowledge.

Knowledge is widespread about the fact that it is a limited trial period, about which times a fee is charged, about when the congestion tax should be paid by car owners and about the possibility to pay by direct deposit with transponder. Six out of ten know that new park-and-ride sites have been built while only one-fourth of county residents know that expansion of the public transport will continue through the end of the year.

One-fifth (21%) think that their possibilities to travel with public transport have improved since 22 August. This applies mostly to residents of the southern part of the county as well as the outer northern region.

However, not more than half know that it costs about SEK 900 per month for a motorist to drive in and out of the inner city during peak period traffic every day. It is more common to believe it costs less than SEK 900. Knowledge of this does not differ between men and women and not between car drivers and public transport users either. Knowledge of this was lacking even amongst motorists who crossed the charge boundary several times a week before the interview. Less than half knew about the monthly cost.

The mass media continues to be the main source of information about the Stockholm Trial although significantly more individuals have actively searched for information when compared to last autumn. Four out of ten have searched for information on a webpage, which is twice as many as before. The percentage that talk with friends or acquaintances about the trial has continued to increase as well as those conducting searches on the Internet. Seven out of ten know that they can find information using the Stockholm Trial webpage today.

The information directed at motorists and public transport users reaches many. Nearly half of drivers in the county have seen the information billboards near the approach roads and just as many public transport users have seen the information in the subways and on the buses. Among those who have travelled to, from, or through the inner city, the numbers are higher.

Eight out of ten say that they have access to a car in their household. Compared to the rest of the county, fewer inner city residents have access to a car. Car trips are more common than public transport trips. Two out of five (41%) made car trips several times a week before the interview; slightly fewer (39%) travelled several times during the week on public transport. This accounts for all trips, not just those across the charge boundary. Compared with the autumn of 2005, frequent car trips have decreased more than frequent public transport trips.

Four out of ten (39%) who live outside of the inner city and who used the car crossed the charge boundary to the inner city during the week before the interview, usually with the inner city as their destination. However, one-fourth travelled through the inner city while having a destination outside of it. Three out of four (74%) crossed the inner city zone using public transport. Among those who live in the inner city, the percentage is 54% with a car and 71% with public transport. More of the residents of the inner city used public transport for trips than they did in the autumn of 2005, while fewer of the rest of the county's residents made trips by car. Frequent trips (9 or more during the week) across the inner city zone have decreased for both inner city residents and other county residents.

Twice as many men as women crossed the charge boundary with a car. Women travel just as often to, from and through the inner city but usually make all trips with public transport.

During the hours outside of the congestion charge period, i.e. weekday evenings and at the weekend, during the week before the interview, six of ten county residents made no car trips to the inner city. If they did, it was only very occasionally. It was more common among inner city residents to use the car on weekday evenings and at the weekend. Seven of ten did this. This is the same percentage who did this during the autumn of 2005.

The reasons for choosing the car for trips to, from, or through the inner city congestion charge hours vary. One-fourth needed the car for work, while for others, time gains, comfort and practical reasons were equally common. Few said that the choice of car was due to poor public transport options. When compared to the autumn of 2005, a greater percentage of those living outside the inner city said that time gain was their reason for taking the car.

Those who used public means of transportation to, from or through the inner city congestion charge hours despite having access to a car did so usually because it worked well. Other common reasons were the difficulty in finding parking places and the high cost of parking places. A small

percentage spontaneously mentions that it is due to avoiding the congestion tax. Among those who switched to travelling more often by public means than by car after the expansion of public transport after August 22, 2005 (which was about one in ten to a certain degree), every other person says the reason for the change is avoidance of the congestion tax.

Compared with the autumn of 2005, only half as many people feel there are big problems with congestion near the approach roads or with poor accessibility in the inner city. Likewise, fewer people feel that poor air quality, noise or traffic safety are problems for unprotected road users. The perception that the problems are less serious now than in the autumn of 2005 is shared by residents of the inner city and the rest of the county. Problems with the approach roads bother residents of the northern county more than those in the southern county.

Many feel there are problems with crowding and delays on buses, subways and commuter trains. Nearly half of all county residents (45%) think that there are problems both with crowding and with delays. Public transport users tend to think that the problems with public transport have increased rather than decreased since January 3, when the congestion tax began.

The majority have the opinion that the Stockholm Trial has at least to some degree contributed to the expected results. Compared to last autumn's investigation the percentage who think the Stockholm Trial to a great degree promoted the decrease in car queues to/from the inner city as well as the decrease in environmental pollution is greater than expected. Many think that it has caused more people to choose public means of transportation to/from the inner city. However, not as many think that the Stockholm Trial has contributed to better public transport to/from the inner city.

The perception that the trial presented positive effects is widespread among both car drivers and public transport users, although public transport users are more positive now just as they were in the investigation last autumn.

The perceived disadvantages of the trial were the high cost of the congestion tax, with one of ten considering the trial to be very expensive to implement. Some think that the trial affects social groups unfairly, that the congestion has increased on certain roads and that it is bothersome to pay the fees. Other points of view included that the trial period was too short, that the infrastructure should have been expanded, that only residents of Stockholm should have been allowed to vote on the referendum, and so on. Car drivers have a greater tendency than public transport users to think there are disadvantages with the trial. The reasons given are similar to those from the investigation last autumn. Compared to that, however, the percentage who said they saw no disadvantages increased from 9% to 16%.

The earlier investigations have shown that the residents' attitude towards the trial is influenced by how it takes place. The expansion of the public transport has the biggest influence. That the trial is only a limited period of time and that a referendum will be held influences many people's attitudes, but not as much. The influence is, however, less now than before the implementation of the congestion tax. Attitudes towards the trial are influenced for the most part in a positive direction, most of all in the case of the public transport expansion.

In the autumn of 2005, a predominance of the county residents were negative about the decision to carry out the Stockholm Trial. Today, when the trial period with the congestion tax is ongoing, the opinion has swayed and a majority (54%) think it is a good decision to carry out the Stockholm Trial while 42% think it is a bad decision. As earlier, residents of the City of Stockholm are more positive than the rest of the county but even the majority of the rest of the county's residents are positive. Among the residents of both the inner city and the outer city of Stockholm, 57% think it is a good decision to carry out the Stockholm Trial.

Car drivers are often negative to the trial, especially those who cross the boundary of the congestion charging zone, while the majority of public transport users are positive. Nevertheless, when compared to last autumn, more car drivers are positive to the decision to carry out the Stockholm Trial. A distinct difference in attitude towards the trial is also evident depending on which political leanings one has. People with right wing sympathies (m+fp+kd+c) are usually negative to the trial while those with leftist sympathies (s+v+mp) are positive. The number of those positive to the trial has increased in both camps since last autumn.

Every other person has changed their opinion about the trial after January 3. More than twice as many of these have become more positive than negative to it. The change in opinion is equal among men and women. The number of residents of the City of Stockholm becoming more positive is slightly higher than the rest of the county.

More than one of five county residents who have access to a car have not travelled by car to, from, or through the inner city during congestion charge hours after January 3. Only one out of ten has crossed the boundary of the congestion charging zone every day and not quite one of five has done so a few times a week. In comparison to how one expected the trial to affect the trips, the actual trips have been less frequent and a few more than expected have not made any trips at all.

For the majority, this means no change to travel habits. There are, though, more who have changed their travel habits than what was expected last autumn. One of four has changed their car travel to, from or through the inner city during congestion charge hours, although before the trial period began 17% were expected to change their car travel. The change most often involves a decrease in trips.

Most people travel the same times today as before, but one of five travels more frequently during charge free time (most common) or tries to avoid the peak traffic hours. The travel behaviour corresponds with the intentions put forth in the interviews last autumn.

Likewise, the travel habits of those using public means during congestion charge hours is unchanged for most (84%). The number of those who drove a car to, from, or through the inner city the week before the interview and who then changed their travel, however, does not correspond with the intentions put forth in the autumn of 2005.

One-fourth of car drivers think that he/she could fairly or very easily have used public transport instead of a car for the same trips to the inner city they made the week before the interview. This is somewhat less than what was expected in the investigation last autumn.

Three of five have unchanged travel time to/from the inner city during congestion charge hours. One of four has shorter travel time compared to before the trial, which is three times as many as those who have a longer travel time. Considerably more have a shorter travel time than what was expected since before the trial, most believed that they would have longer travel time rather than shorter.

Most (72%) have paid the congestion tax themselves. About one of ten report that their employer or company have paid the tax and a few percent have paid themselves as often as their employer or company.

The investigation reveals that the majority in the county are in favour of the decision to implement the Stockholm Trial. After the start of the trial, the perception has become considerably more positive to it. This is also seen when we ask how people would vote today in a referendum vote for or against a permanent implementation of congestion charging, if the money were to go back into the region. In that case, 48% would probably vote yes and 43% would probably vote no. The number of yes-votes has increased by 18% in comparison to last autumn.

Among those who believe that the trial will lead to positive effects in the form of better access, less environmental pollution and improvements to public transport, there is already a majority of yes-votes for a permanent introduction of environmental charges/congestion taxes. Women are to a greater degree willing to implement them right now. Most likely, there are more yes-votes than no-votes across the age groups, except for age group 45-54.

Among residents of the City of Stockholm, whose votes are crucial for the delegation's decision for a permanent congestion tax or not, 52% would probably vote yes today and 40% would probably vote no.