Facts and results from the Stockholm Trials

First version – June 2006
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Presentation of Expert Group
The Expert Group consists of eight traffic experts with various specialities. The group read all documentation and then, during three intensive full-day seminars, drew the conclusions presented in this summary of the evaluation of the Stockholm Trial. Several group members have in different ways participated in preparatory tasks prior to the evaluation and also conducted follow-up activities during the course of the trial. In August, when further reports will be available, the evaluation will be supplemented by additional material.

The Expert Group is chaired by Jonas Eliasson and its secretary is Lena Smidfeldt Rosqvist. Other members are Staffan Algers, Karin Brundell-Freij, Cecilia Henriksson, Lars Hultkrantz, Christer Ljungberg and Lena Nerhagen. A more detailed presentation of group members is contained in Appendix 1.

Effects of the congestion tax in Stockholm were as predicted
Expectations concerning the Stockholm Trial were many, as were uncertainties about how its effects would be influenced by the fact that the trial period was limited. Numerous questions centered on whether such a limited trial period would result in the large effects indicated by traffic models - road users/passengers might choose to “sit out” the trial period and not adjust their travel patterns. Now, when we to a large extent know what the actual effects were, many of these questions can be answered.

Even before the Stockholm Trial started, most people were well aware that motorists are sensitive to economic incitement so expectations that the congestion tax would reduce traffic volumes were therefore well grounded. In the first place, it was anticipated that the reduction would be seen near the congestion-charge zone, with a relatively quick fall in the reduction as distances to the charge zone lengthened. Even if prognoses were made regarding the effects of the Stockholm Trial, the exact size of the reduction was naturally uncertain.

Expected effects on accessibility were more doubtful than those for traffic volumes. There was reason to believe that limited traffic-volume reductions could lead to a “leap” effect in the form of less congestion but there was much uncertainty about this since the connection between traffic volumes and travel times/congestion is very complicated.

As to traffic passing over the congestion-charge zone cordon, it was expected - based on developments in London - that the Stockholm Trial would result in many motorists leaving their cars at home and instead travelling by public transport or, to a certain degree, by cycle. The expected increase in travel by public transport was not entirely due to the congestion tax - the expansion of public transport as part of the Stockholm Trial also played a role. As a direct consequence of reduced traffic, road safety
for motorists was also expected to improve, particularly as regards whiplash injuries. However, the trial period is all too brief to enable these changes to be measured.

The Stockholm Trial also has a distinct environmental profile, which is natural since vehicle traffic contributes to a number of our most urgent environmental problems, not least in large cities. Even if the congestion tax, as initially proposed, was primarily aimed at reducing congestion, it is obvious that by reducing traffic it is also expected to have effects on the environment and citizens’ health. Uncertainty regarding expected effects in the form of reduced exhaust emissions derived from uncertainty about the size of traffic reductions.

It is, however, not obvious which health effects - and their size - will result from changed emission volumes. The connection between vehicle emissions and air-pollution levels affecting health in Stockholm are extremely complicated.

The Stockholm Trial was expected to result in only small changes in noise levels, since large traffic-flow reductions are necessary to achieve improvements in noise levels. A 50% decline in traffic flow would yield a fall in noise levels of 3 dBA, a barely audible change.

What change citizens would perceive in the city environment due to the Stockholm Trial was a matter of great uncertainty, not least because the city environment is a complicated concept that lacks a clear-cut definition.

The exemption of clean vehicles from the congestion tax, for example, was expected to lead to an increased number of such vehicles in Stockholm traffic. It was also expected that there would be an increased number of company cars since this is category of users less price-sensitive than others.

Finally, we were all curious as to whether the effects of the Stockholm Trial would be felt even without monitoring, i.e. whether Stockholm citizens and visitors would spontaneously note them.

**Documentation for the summary of our conclusions**

The evaluation of the Stockholm Trial includes a large number of monitoring and studies that date from three periods, two prior to the start of the Stockholm Trial and one after: (1) August 2005, with expanded public transport; (2) autumn 2005; and (3) the months after the introduction of the congestion tax in January 2006. Individual studies have been initiated in cooperation with the Swedish Road Administration, the Stockholm County Council regional planning and traffic unit, Stockholm Transport (SL), various research institutes, certain City of Stockholm administrative offices and experts from other bodies, organizations and companies.

The studies cover a large number of fields, including not only travel habits and their effect on vehicle traffic and public transport but also envi-
ronmental consequences, effects on the retail market and business economy, pedestrian and cycle traffic, changes in the city environment and effects on national and regional economies. Many of the effects of the Stockholm Trial are strongly dependent on external factors, for example economic trends in the Stockholm region and Sweden as a whole. As a result, the evaluation also includes studies of the retail market and the general economic situation. Between monitoring periods before and during the Stockholm Trial there were external factors that influenced effects monitored in the various studies. The most important factors were that petrol prices went up and the Södra Länken bypass tunnel was opened. These and other such factors that affected results have been taken in account in the conclusions made by the Expert Group and herewith presented.

A comprehensive follow-up and evaluation of the effects of a project the size of the Stockholm Trial is a difficult task which has not been made easier by the short time available to conduct the follow-ups. Regarding methods, there are numerous factors that are difficult to handle. Of these, we have already mentioned the influence of external factors on effects. Several of the studies took the form of panel studies, i.e. the same persons were questioned about their behaviour prior and during the Stockholm Trial. These panel studies have many advantages but also call for caution when drawing conclusions since there was an age disparity between monitoring prior to and during the trial. Moreover, the trial is not yet completed and much of the documentation is based on studies from spring 2006, that is, after half of the trial period.

In our evaluation of the result/conclusions of studies, we have taken into account the stability of individual studies, the expected stability of monitoring results and which monitoring methods were used. We have also taken account of the importance and potential of various effects. Thus, we do not base our evaluations solely on the results of individual studies but also on appraisals of significance and general applicability vis-à-vis effects.

**Results**

**Vehicle traffic declined more than expected**

Traffic goals of the congestion tax were that the number of vehicles passing over the charge cordon during the morning and afternoon/evening peak periods should decline by 10-15% and that accessibility should improve on Stockholm roads with the heaviest traffic. The congestion tax was designed to meet these goals but uncertainties regarding the effects of the tax, as earlier mentioned, were many. Numerous monitoring, of various types, were conducted and analysed to produce information on traffic changes.

The main features of the traffic reductions are crystal clear. The Stockholm Trial cut traffic flows - more than expected, in fact - the decline
being surprisingly stable, taking into account normal seasonal variations during spring. In addition, the effects of the trial were seen further out from the charge zone than we initially expected - traffic volumes declined at locations far from the charge cordon. Consequently, many of the feared side-effects - on link roads at the city’s outskirts, for example - were unfounded. The decline in traffic volumes was measured via traffic monitoring but has been demonstrated in special studies as well.

Exactly as expected, the biggest traffic decline was in vehicles passing over the charge cordon, which includes all approaches to the inner city. For an entire day’s charge period (24 h), the decline was about 22%, equivalent to 100,000 passages over the charge cordon.

The decline in vehicles passing over the charge cordon was biggest during the morning and afternoon/evening peak periods. The biggest decline of all was during the afternoon/evening peak period, which can be probably be partly explained by the fact that during the afternoon/evening travel is not dictated to the same extent by time/destination as in the morning peak period’s journeys to work. Traffic also declined during evenings after the charge period. The reason may be fewer outward/return journeys by car during the charge period, resulting in fewer return journeys during evenings after the charge period. We hope to to provide a better explanation in August in connection with our updated analysis, in which we will analyse the major travel-habits survey.

The traffic decline on the southeast approach road was bigger than the average decline for the entire charge zone. The decline to/from Lidingö, on the other hand, was less than the average. This was expected, since traffic to/from Lidingö that passes through the charge zone within a 30-minute period is not subject to the congestion tax. Regarding the fact that the traffic decline is bigger from south/southeast, it is conceivable that the reason is that the percentage of through traffic is higher and consequently more drivers can choose to drive round the inner city to avoid the congestion tax. Hopefully, the travel-habits survey will provide a more detailed explanation.

Traffic flows on big inner-city streets during the charge period declined but not as much as over the charge cordon. This is natural since the traffic flow in the inner city also includes vehicles belonging to people who live there, etc., who do not leave the charge zone but use their vehicles for transport within the zone. There are also signs from studies other than traffic monitoring that motorists who do not need to pass over the charge cordon benefit from the decline in congestion and, in fact, now use their cars more often. This could partly explain why the traffic-flow decline in the inner city is lower.
Figure 1. Change in traffic flows over charge cordon during charge period (6.30 a.m.-6.30 p.m.) per direction.

Fears of collapse on Essingeleden and other bypass routes were unfounded. Differences everywhere are small if compared to normal week-by-week variations.

Traffic in Södra Länken has continually increased since it opened in October 2004. It is impossible to determine to what degree the increase in 2006 is due to the congestion tax. Normally, new infrastructural devel-
opments have a long “running-in” period and, in addition, the large number of people moving to Hammarby Sjöstad (a new housing district in the southern part of Stockholm) has certainly led to traffic increases. These effects, together with an accident causing lane closures on Essingeleden in October 2005 (a floating crane collided with one of the bridges), influenced both traffic volumes and the reliability of traffic monitoring. We have taken account of this in our evaluation.

The only approach that deviates from the pattern of shorter travel times is Värmdövägen (from Nacka Centrum to the entrance to Södra Länken). The increased traffic in Södra Länken also causes longer queues on Värmdövägen westwards in the morning peak period. Travel times, however, are significantly shorter than previously after this point, i.e. the continuation of Värmdövägen-Stadsgården westwards in towards the city. There is a similar trend on Nynäsvägen.

According to manual monitoring of approach-road traffic, the number of commercial vehicles passing the charge cordon has also declined. The manner in which commercial drivers have changed their travel habits is, however, uncertain.

Figure 2. Change in traffic volumes (weekdays, 24-hour period), April 2005 compared to April 2006.

Congestion rose at the end of April in line with the annual spring increase in traffic and it has been discussed whether this was due to the effects of the congestion tax declining over time. It is true that congestion has increased but it is the result of a normal seasonal increase in traffic. The effects of the traffic decline are, however, the same in a month-by-month comparison with earlier years. A probable contributing factor to the increase in congestion - in addition to the increase in traffic - is that the number of cyclists and pedestrians also went up with the arrival of spring. They also utilize traffic-system capacity. Another interesting reflection is that if the traffic decline is equally large during the entire period, taking account of the first half-year’s seasonal variations, it means that additional vehicle journeys made during the spring were just as much affected
by the congestion tax as those made when the Stockholm Trial began during the winter.

**Accessibility improved**

A consequence of vehicle traffic declining is that accessibility improved and travel times fell. This had a large, positive influence on the reliability of travel times, i.e. travellers were now more certain that a journey could be made within a given period. Travel times for vehicle traffic declined significantly in and near the inner city. Particularly large declines were seen on approach roads, on which queue times fell by one-third during the morning peak period and by one-half during the afternoon/evening peak period. This is an important improvement for car commuters to/from the inner city since it means that travel times are shorter and more reliable. When high congestion occurs, disparities in travel times on the same stretch with different traffic conditions - which can vary from day to day - are very big.

![Figure 3. Change in travel times (morning peak period), April 2005 compared to April 2006. Inner city enlarged (right).](image)

The relatively high congestion on Essingeleden means that travel times vary greatly from week to week, even if traffic volumes are generally unchanged. In the light of the traffic increases we can see on Essingeleden, it is reasonable to believe that travel times have increased. However, in the monitoring done between 2005 and 2006 no increase in travel times can be seen.

Traffic increases in Södra Länken lengthened travel times there compared to 2005. With available data, it is impossible to say how much of the traffic increase is due to the congestion tax and how much is the result of a traffic increase that would have occurred irrespective of the congestion tax. We can, however, say with certainty that there is great deal here that is not the result of the Stockholm Trial.

It is clear that the decline in traffic volumes and improved accessibility has led to a better work environment for commercial drivers, seen in vary-
ing measure in all studies with commercial drivers - bus drivers, taxi drivers, couriers and trades people - conducted before and during the Stockholm Trial.

**Traffic declines result in less damage to the environment and better health**

Vehicle exhaust emissions constitute a large part of the total amount of pollution in a city. Released into the air, emissions mix with other pollutants and thus affect air quality. Different pollution or exhaust-emission substances have various types of effect. Sometimes it is the level of pollution - numerous emissions mixed in the air - where people are that is most significant and sometimes it is the total amount of emissions. Regarding carbon-dioxide emissions, which are important for the greenhouse effect, it is the total amount of emissions that is decisive. Air quality, mainly measured by particle levels, affects the health of people in a city, resulting in increased heart, vascular and lung diseases as well as increased discomfort for sensitive groups (asthmatics and people with other bronchial disorders as well as those suffering from heart and lung diseases).

Total exhaust emissions caused by vehicles is due to both total vehicle kilometres travelled - i.e. the total of distances covered - and exhaust-emission factors, i.e. emission of different substances that each vehicle emits per driven kilometre.

Total kilometres travelled multiplied by emission factors results in total amount of exhaust emissions (expressed in, for example, tons/year) for different substances. Emission factors are influenced by vehicle-park composition and how vehicles are driven. For example, a driving style with many speed variations produces more emissions than one with a more uniform speed. These relationships are complicated and it is therefore difficult on the basis of input data to exactly calculate the result of the Stockholm Trial in the form of reduced emissions. Emission calculations carried out were done on the basis of various emission models which differ in regard to which factors are taken in account when making the calculation. However, calculation results are similar. Assumptions made in the calculations probably mean that, in any case, effects have not been exaggerated. The calculations primarily show that a decline in traffic volumes leads to reduced emissions but also that it is changes in vehicle-park composition that are decisive as regards how much the emission of particles/nitric oxides falls.

The Stockholm Trial led to reduced emissions of both carbon dioxide and particles. The reduction of carbon dioxide is approximately proportionate to the decline in vehicle kilometres travelled, which means that the effect of traffic on exhaust emissions dropped by 2-3% in Stockholm County and about 14% in the inner city. As the result of one measure - the Stockholm Trial - this is a major reduction even if the decline in Stockholm County can only be seen as an interim step if the aim is to meet national climate goals. Carbon dioxide emissions are the traffic emissions most difficult to reduce.
The total decrease in the amount of particle emissions is similar to that for traffic volumes but for these substances the most significant factor is where the reductions take place since they contribute to local pollution levels. The Stockholm Trial has led to an approximate decrease in the effect of traffic on pollution levels by one-twentieth for the County of Stockholm and one-tenth for the inner city. According to the Stockholm County Council, reduced use of studded tyres is an important step in meeting the environmental quality standard for particles. In the case of Hornsgatan in Stockholm’s Söder district, a 10% fall in the use of studded tyres would result in a reduction of pollution to levels equivalent to the decrease that the City of Stockholm’s Environmental Office calculated that the congestion tax would produce. However, the fact is that the congestion tax, in addition to reducing particle counts (measured in PM10) at street level, even leads to a reduction in the level of smaller exhaust particles, which is also a benefit to health - a benefit that cannot be gained by reducing the use of studded tyres.

There are also environmental quality standards for nitrogen dioxide, NO₂. The NO₂ count at street level is decided not only by vehicle emissions but even by factors such as the occurrence of other substances. Vehicle emissions of nitric oxides (NOₓ - not only NO₂) have declined continually during recent years due to stricter vehicle-exhaust regulations. The effect of this decline on NO₂ counts at street level in Stockholm’s inner city is, however, much lower. This is the result of the complexity of, for example, chemical reactions. Thus, it cannot be expected that the congestion tax will be of any great significance in meeting NO₂ environmental quality standards.

Exposure to particles affects the population’s health and mortality rate. Calculations based on the connection of congestion-tax effects to early mortality due to exposure to air pollution show that traffic reductions resulting from the Stockholm Trial save about five otherwise “lost” years. That is also the expected reduction used in the cost-benefit calculation for the Stockholm Trial. New research results, presented in an evaluation report, indicate a significantly higher saving. Calculations based on the new research results point to the avoidance of about 25-30 early deaths, equivalent to about 300 years.

Bearing in mind that there is thus an obvious risk that health effects may be larger than what has traditionally been expected, one should not ignore the importance of reduced exposure. To get the best result from a measure aimed at reducing exhaust emissions, activities should be focused on areas where population density is highest and, consequently, many people are exposed to emissions affecting their health. Via the congestion tax, emissions can be controlled according to where the tax is levied. Consequently, the effects of the congestion tax have a larger influence on health per given emission amount than a petrol-tax increase. The emission reduction in the inner city resulting from the congestion tax has, for Stockholm County as a whole, a health effect that is about three times as big as the health effect that would have resulted from a decline deriving from a rise in petrol prices evenly distributed throughout the county.
As expected, the Stockholm Trial in general has led to only small changes in noise levels since large traffic-flow changes are necessary to perceive an increase/decrease of noise levels.
Anything less than 3 dBA will not be perceived as a difference in noise levels which, as regards traffic, is equivalent to about a doubling or halving of traffic volumes.

Calculations of noise-level changes due to the Stockholm Trial reveal changes of 1 dBA or, at most, 2 dBA for average levels over a 24-hour period. There are, therefore, an extremely small number of locations where changes in noise levels can be perceived. However, even minor noise-level changes of 1 dBA mean that the part of the population that feel disturbed by traffic noise declines. Perception of noise levels can also improve if one experiences less congestion and vehicle traffic. In the city-environment study there are results indicating that people believe there is less noise now in spite of the fact that, in principle, it is impossible to perceive the small noise reductions that have taken place.

Noise continues to be a big problem in Stockholm, as in many other places in Europe, and is now the subject of a special EU directive. One goal is to create quiet zones, which puts large demands on traffic reductions. It is difficult to see how such traffic reductions could be achieved without very effective steering measures to limit vehicle traffic.

Public transport important part of the Stockholm Trial
Accessibility for bus traffic to/from and in the inner city has increased. Since inner-city timetables were not adjusted for the trial period, improved accessibility has not significantly shortened travel times for inner-city buses. Punctuality has probably improved and as regards bus traffic passing over the charge cordon travel times have shortened considerably.

Efforts to improve public transport (park-and-ride sites, expanded bus and light rapid-transit train services) did not, on the basis of current documentation, yield any visible effect on the total number of public-transport journeys during autumn 2005 - before the start of the Stockholm Trial. That is not say there is no such effect, just that, if it exists, it is too small to register in SL’s passenger statistics or in the travel-habits survey conducted in autumn 2005. It is indeed improbable that the public-transport expansion would not have any effects on the total number of public-transport journeys but adequately detailed analyses and statistics enabling such an increase to be identified are not yet available. SL’s onboard surveys on the new buses indicate that it has enticed motorists to switch to public transport but their number is still too small to make an impression when considering total public-transport travel. Totally, travel with SL was about 2% higher in autumn 2005 compared to autumn 2004 but that increase is believed to be due to higher petrol prices.
Public-transport travel was about 6% higher in spring 2006 than in spring 2005. The congestion tax seems to have increased public-transport travel by about 4.5%, while higher petrol prices and other external factors are probably responsible for the rest of the increase (about 1.5%). Congestion on public transport (measured by the number of standing passengers) in-
creased somewhat on the Underground and decreased on commuter trains. Overall, congestion seems to be unchanged, probably partly due to expanded public transport.

Another question is if the congestion tax would, in fact, have reduced vehicle traffic even if public transport had not been expanded. Expanded public transport, as mentioned above, has as yet certainly not provided any evidence of an increase the number of public-transport journeys, but it is quite conceivable that it boosted the effect of the congestion tax by making the switch from car to public transport easier. If that is the case, part of the effects of the congestion tax should instead be registered as an effect of expanded public transport.

Still, we believe that that effect, even if it exists, must be small. We base this belief on the fact that onboard surveys on the new buses show that, between autumn 2005 and spring 2006, the number of new passengers who earlier used their cars for transport was tiny compared to the reduction in the number of passages over the charge cordon. Of the vehicle-traffic reduction of 22% over the charge cordon, at the most 0.1% can be ascribed to expanded bus traffic.

Problems with commuter-train traffic during the winter seem to have led to reduced travel on these services. It is unclear which alternative mode of transport passengers chose. Some have certainly used other public-transport alternatives or refrained from travelling while others have instead used their cars. Commuter-train problems should therefore, to a certain degree, have limited the traffic reduction resulting from the congestion tax.

**Road safety improved as a result of reduced traffic**

Road-safety effects are, without exception, difficult to evaluate and the short period of the Stockholm Trial makes it hard - not say impossible - to draw conclusions on the basis of follow-ups of actual and reported accidents during the trial. Evaluations of the road-safety effects of the trial are therefore based on estimates and the connection between road safety and changes in traffic volumes, traffic flows and speed levels.

Research shows that road safety is mainly influenced by changes in traffic volumes and speed levels. Since traffic declined as a result of the Stockholm Trial that means that even the estimated number of accidents within the charge zone in which people were injured is lower. The size of the reduction in accidents is, of course, uncertain but based on model estimates the number of accidents where people were injured should have fallen by about 9-18%. Reduced congestion should also have led to higher speeds, resulting in an expected increase in the number of accidents where people were injured. This effect, however, is not as big as the effect of traffic reductions.

The total effect of the Stockholm Trial on road safety is undoubtedly judged to be positive since the positive effects of the traffic reduction are expected to be bigger than the negative effects caused by higher speeds. A
large number of road accidents within the charge zone occur during the charge period. A cautious estimate is that the Stockholm Trial has led to a reduction in the number of accidents within the charge zone where people were injured by 5-10%. Converted to yearly values, this would equal an annual reduction of between 40 and 70 accidents in which people were injured. This can be seen in the light of the fact that, on average, 2,155 people are injured and 23 people die in road accidents per year in Stockholm County.

1 Note: We are talking about the effect seen to date. It is quite likely that, eventually, more detailed statistics and analyses will reveal an effect.

The majority of those who are injured, both in the county and inner city, are motorists. In the inner city, just over a third of those injured are unprotected road users.

**Difficult to judge whether Stockholmers think the city environment has improved**

The city environment is complex and diffuse concept. It is difficult to find a common, clear-cut definition of what is meant by a “good” or “improved” city environment. It is also difficult to measure these types of effect. Since a perceived improvement in the city environment is one of the goals of the Stockholm Trial we have, in spite of documentation that is hard to analyse, tried to make an evaluation. To draw conclusions from the study carried out is made difficult not only by the above-mentioned general problems but also by the completely different weather conditions during the two monitoring periods. Our conclusions are therefore very cautious.

The result points to perceived improvements of exactly those factors for which measured changes can be demonstrated, i.e. those connected to traffic reductions. In the city environment study, citizens feel there is an improvement in traffic tempo, air quality and vehicle accessibility. The same tendency is seen in interviews with cyclists in the inner city and children living in the inner city. Inner-city children’s perception of the city environment has very clearly improved and many cyclists think there are fewer cars in the inner city and that the traffic environment has got better. Perception of things that have got worse mainly concerns accessibility - by foot and cycle and on public transport. The result does not support any clear-cut or unequivocal appraisal of whether the city environment in general has improved. Perceptions of accessibility by foot or cycle are strongly influenced by the weather and season and monitoring took place at different periods. However, the conclusion is that effects clearly associated with traffic changes can be seen in how the city environment is perceived.

**Many ways of adjusting to the new situation**

If the congestion tax is introduced permanently, there will be both short- and long-term adaptations. Because the Stockholm Trial is just a trial – and a short one at that – one can only expect short-term adaptations. This is all we have measured and all we can evaluate. In the long term, there
will also be localization effects, discussed in the section about the effects on the regional economy. There are even possible long-term effects at an individual level. For example, it may be, in a slightly longer perspective, that part-time workers will reorganize their work time to reduce the number of journeys subject to the congestion tax.

There is a wealth of different strategies for adjusting to the new situation created by the Stockholm Trial. We have searched the evaluation material for anything sufficiently of note to show up in monitoring and test results. At an individual level, there are even more variations than the ones we comment on. It is important, in the meantime, to remember that in discussions about the different adjustment strategies, only a small portion of county citizens’ journeys are affected by the congestion tax. Prior to the Stockholm Trial, county citizens made about 300,000 vehicle journeys per day over the charge cordon during the charge period. This is equivalent to 14% of all car passages and 7% of all passages during one work day in the county. Most of these journeys were work-related.

There are two different types of adaptations which point in two different directions. One is to adapt in order to avoid the congestion tax one way or another, which reduces traffic. The other is to utilize the lack of congestion which is the result of the reduction in traffic, which counteracts the reduction in traffic. A further adjustment to avoid the congestion tax is to use a clean car which – not unimportantly – reduces damage to the environment. Increased use of clean cars does not, however, reduce congestion.

It is very clear that vehicle traffic has fallen, especially in the inner city. Not only private motorists but also commercial traffic seems to have adjusted travel habits. According to manual calculations of approach-road traffic over the charge cordon, car traffic has been reduced by 30%, light trucks by 21% and trucks by 13%.

There is much uncertainty over how many of car journeys have instead been replaced by travel on public transport. According to SL, some 40,000-50,000 new trips are being made with public transport. If this is so, it is not even half the number of car journeys no longer being made over the charge cordon. Hopefully, analysis of SL’s measurements and the summer’s survey of travel habits in Stockholm County will provide a clearer picture of what has occurred. The new park-and-ride sites introduced for the Stockholm Trial have largely been filled, but it is not clear if this is the result of the congestion tax or the result of a need which has now been met. The increase in park-and-ride sites (approximately 2,000 cars per day) is almost insignificant, however, in relation to the number of vehicles passing over the charge cordon (about 530,000 passages per 24-hour period prior to the introduction of the congestion tax) or to the reduction in traffic (about 100,000 fewer passages per 24-hour period). Each individual vehicle can make several journeys.

Several of the results from the evaluation imply that some motorists have changed the time at which they travel. This is, however, not the only ad-
Justment to journeys, as some studies of adjustment of travel times prior to the Stockholm Trial showed. Journeys have more likely been reorganized to become fewer or more efficient and also changed to include other means of transport.

Calculations of the average number of passengers per car also show that shared travel has not increased to any measurable degree. The average number is stable at 1.27 people per car.

Because public transport, pedestrians and cyclists have not collectively increased as much as vehicle traffic has decreased, this must mean that some travel has simply “disappeared”, especially as cycling has, moreover, decreased in the monitored periods. The adjusting mechanisms remaining as explanation for what has happened with car journeys are that people have chosen other routes or closer destinations, that people have coordinated errands so they can be achieved with fewer trips and that some trips are simply not being made.

Despite the fact that approximately half the vehicle journeys over the charge cordon which have “disappeared” are now being made by public transport, it is interesting to note that the “amount of travel” in the previous situation is not a static fixed number which can be replaced, but that there is a large adjustment potential in simply reducing travel in different ways. The early result of surveys of travel habits seems to point to a reduction in the frequency of travel – people are not making as many trips as they did prior to the introduction of the congestion tax. A reduced frequency of vehicle journeys over the charge cordon can even be seen in the study of commuter trips from the Stockholm/Mälaren region to Stockholm’s inner city and in the study on attitudes, where people now say they make fewer trips to the inner city. Even large changes in heavy traffic (seen in the manual calculations of approach-road traffic) support the reasoning and explanations of route planning and information given by transport companies.

Adjustments in the form of taking advantage of reduced congestion on roads are seen, for example, in the study of work travel to/from two large workplaces. Among these commuters, there are now several who don’t need to cross the charge cordon and who now travel in peak-period traffic. Among these commuters who live and work outside the charge cordon, the percentage choosing a car as transport has increased somewhat. Further examples of this are that because there is a smaller traffic reduction in the inner city than over the charge cordon, people now choose Klarastrandsleden, because it is now possible to travel there without hinder. There are, therefore, many people who do not pay, but who are still able to take advantage of improved accessibility.

**People have become more positive as they have experienced the effects**

We have not yet had access to the complete analysis of the attitude survey presented in the summer. Conclusions are based on the “monthly indica-
tors”, excerpts from result tables from the attitude survey as well as studies of company attitudes.

It is clear that both the public and companies have become increasingly positive towards the congestion tax and the Stockholm Trial, as they have gained their own experience and as benefits have begun to appear. This is normally what the acceptance of change looks like: Without individual experience, people see almost exclusively barriers and costs, but with individual experience they begin to discover the advantages and benefits gained for these costs. There is, however, a lot of uncertainty over how fast these changes in attitude take place.

The percentage of Stockholm County citizens who think there is a problem with congestion has fallen compared to the period prior to the introduction of the congestion tax. Even attitudes to the Stockholm Trial have become more positive during this time. In autumn 2005, about 55% of all county citizens believed that it was a “rather/very bad decision” to conduct the congestion-tax trial. Since the congestion tax was introduced in January 2006, this percentage has continuously fallen. In April and May 2006, 53% believed that it was a “rather/very good decision” while 41% believed that it was a “rather/very bad decision”. Significantly, even those travelling by car to/from the inner city during the charge period in the most recent two 24-hour periods have become more positive by several percentage units.

As with the general population, companies have moved from being primarily negative to more positive, both to the Stockholm Trial and to the congestion tax as a permanent measure. The shift is more apparent for the trial itself than for the congestion tax as a permanent measure.

Companies are, as far as we can tell, united in their criticism of the inconvenience and the administrative costs the congestion tax bears in its current form. There is even evidence that companies still believe that the system is hindering growth, but while there were opinions before the Stockholm Trial that both the individual company and other companies would be affected negatively, opinions are now more moderate regarding the individual company’s negative development.

In attitude surveys, it is clear that the reason for choosing to drive a vehicle compared to before the Stockholm Trial is now increasingly that it is possible to save time compared to other means of travel. There has been a decline among those who choose public transport due to too much traffic and queuing. This is interesting, because it means that improvements in accessibility which can be measured objectively have also been visible “to the naked eye”.

It also appears that people using public transport are very satisfied with the direct buses.

Motorists with company cars are a group where it is harder to judge the adaptations made. This is because the actual cost of the congestion tax for
private travel is sometimes paid for by the employer, sometimes by the employee. There is also an in-between variant, where the employee pays via a gross-salary deduction, which means that the actual cost of the congestion tax is significantly reduced. We do not have a clear picture of how the different variants have been applied during the Stockholm Trial. In the study of two workplaces, it was clear that Swedish Postal Service employees will eventually be debited for congestion-tax charges for private journeys.

It is reasonable to say that company-car motorists pay less, on average, to pass the charge cordon than private motorists. We also expect company-car motorists to be less price-sensitive because of their on-average higher incomes. Manual calculation of approach-road traffic also shows an increased percentage of company-car motorists passing over the charge cordon.

The technical system works

We would have liked an assessment of how the technical system has worked. Because we do not currently have this kind of evaluation we can only make an overall estimation. We know that we cannot assess how complicated the congestion-tax system is for each individual and/or organization at an overall level.

We can, however, conclude that on an average day in May 2006, 371,300 journeys took place over the charge cordon, resulting in 115,100 tax decisions and income of more than SEK 3 million. Of these 115,100 tax decisions, 100 were investigated by the Swedish Tax Agency and five were appealed. The Swedish Road Administration customer-service unit received on an average day in May 2,200 calls, as opposed to an expected 30,000 calls. Based on this, our assessment is that the system generally worked well. The case studies carried out imply the system needs adjustment to reduce inconvenient administration for companies.

There is reason to note that red-tape costs for both individuals and companies are now absent from cost-benefit evaluations. It is probable that many experienced the initial inconvenience as high but that it has fallen as people have learned how payments can be made in the simplest way.

Benefits and costs distributed differently

Results of the travel-habits survey and analysis of distribution effects for various group affiliations are not yet available. This section will therefore be supplemented in August with an analysis.

Based on the first evaluation of the expansion of public transport in the autumn of 2005, it was, as expected, mainly people of middle income who changed from car to public transport, as well as people with children and people born overseas. It is normally primarily people of middle income who change, which can be explained by the fact that people of low income already use public transport and that the incentive for people of high income to reduce their car travel is not as strong.
The main “winners” of the congestion tax are:

- Public-transport travelers who get a better choice.
- Those who drive cars without passing the charge cordon and therefore have shorter travel times at no extra cost.
- Cyclists who appear to have a better traffic environment.
- People who value their time highly and think that more time is worth money.
- Commercial drivers who gain a better work environment (bus drivers, taxi drivers, truck drivers, etc.).

The main “losers” are:

- Those who drive a car over the charge cordon and for various reasons cannot adapt their travel and who don’t think more time is worth money.
- Those who are “forced off” the roads.
- Public-transport passengers who experience more public-transport congestion.

**Marginal effect on regional economy**

The regional economy may be affected both in the short and the long term. The effects on the economy depend to a large degree on whether – and in what way – the congestion tax is returned to the region. The effects of the Stockholm Trial on the economy have been investigated in several different studies. Most important, an overall economic analysis of the trade outlook and trade developments has been carried out in the county. Moreover, studies of the retail market, visitor-intensive activities, handicraft companies, driving schools, rubbish hauling, delivery traffic, taxis, transportation for the sick and handicapped and courier firms are also included. It is clear that the economy is dependent on a functioning road-transport system.

The short-term effect on the retail market and other sectors studied shows only small average effects. The effects often disappear among other factors which have more influence, for example new retail shops. Revenue measurements carried out show that the Stockholm Trial has had small influence on the region’s retail market. The durables survey in shopping centres, malls and department stores during the Stockholm Trial period shows that these have developed at the same rate as the rest of the country. Street-level durables sales have fallen, but the time series is too short to be able to draw conclusions (partly because VAT reporting for small companies is a long way behind).

The basis on which we judge long-term effects on companies is how companies themselves expect to act.
Earlier experience, including that from London, implies that the congestion tax results in small effects compared with the regional economy as a whole. Normal variations in the economy are generally larger than the per year effects of the congestion tax. The Stockholm Trial’s contribution to total production in Stockholm County was 1 of SEK 750 billion. The congestion tax has in most cases only a marginal effect on a company’s total transport costs. For households, the congestion tax has, according to the Stockholm Trial model, an effect of about one per thousand of total disposable income per year. This means that purchasing power in the county has not been significantly affected, but for individual households the tax can have tangible consequences.

Model calculations of the changed attractiveness of different areas are very sensitive to the value of time – pounds and pennies for what time is considered to be worth, what is assumed. The analysis shows many small changes that are uncertain because of this sensitivity to which assumptions are made. The changes are also small in comparison with generally increased pressure from a growing number of citizens and workplaces in the region. Even the influence on house prices is not of great significance. The long-term effects according to the model are not greater than the normal price variations between two quarters.

**Cost-benefit analysis shows the congestion tax is profitable**

A cost-benefit analysis is a means of systematically trying to summarize the effects and costs of a particular measure. The analysis is carried out to establish whether a measure is “worth the money”, in other words whether the value it creates is greater than its cost. The Stockholm Trial – regarded as a short trial which, after completion, is not assumed to be repeated – creates a cost-benefit loss of about SEK 2.6 billion. Investment in and operation of the congestion-tax system makes up the greater part of the loss. This does not take into account the value of knowledge and research. This perspective is of limited interest; that the investment in the congestion-tax system was not recouped during the trial period is not a surprise.

Making the congestion-tax system permanent is calculated to yield a significant annual cost-benefit surplus of about SEK 760 million (after deducting operating costs). It would take four years to pay back the congestion-tax system’s investment costs in the form of social-economic benefits. This is a very short payback time compared, for example, with road or public-transport investments which, in favourable scenarios, have a payback time in terms of cost-benefits of 15-25 years. From a cost-benefit perspective, the most relevant basis for a decision is really to ignore the cost of the investment – the Stockholm Trial cannot be undone and the investment made cannot be recouped. But the congestion tax is still cost-benefit positive, even when the cost of the investment is taken into account.
The cost-benefit surplus of the congestion tax is found, for example, in shorter travel times (worth SEK 600 million per year), increased road safety (SEK 125 million per year); and health and environmental effects (SEK 90 million per year). Revenues from the congestion tax are calculated at SEK 550 million per year (after the system’s operation costs have been deducted). Every krona generated by the congestion tax results in a further 90 ore in cost-benefit gain.

Increased bus traffic is considered unprofitable from a cost-benefit perspective, both during the Stockholm Trial and if it was made permanent. Benefits are calculated to reach SEK 180 million per year, compared to a cost-benefit operational cost of SEK 340 million per year. The result should be treated carefully, however, because it is not unusual for public transport to be considered unprofitable according to a cost-benefit analysis in strict terms, while still being considered worth operating for different reasons.

Environmental effects in terms of road safety, climate and health are worth somewhat more than what the congestion tax costs road users via various types of sacrifice. Valuing and estimation of both road safety and the environment is subject to uncertainties. This uncertainty is obviously not desirable, but neither does it play a significant role in the total cost-benefit evaluation of the project.

The cost-benefit analysis looks at the average effects on all individuals in the community. For particular individuals, the consequences of the congestion tax can be both positive and negative. The net effect for different individuals depends to a large degree on how the income generated from the system is used.

Based on older research into the health effects of traffic, the congestion tax appears above all to be an accessibility measure and improved accessibility is where the big cost-benefit values lie. Health effects are small compared to the value of increased accessibility when using the somewhat older relation between emissions and health. If you instead use the latest research on the effect of traffic on health, the congestion-tax health effect increases. The total value of the environmental and safety improvements would almost double.
Discussion

Big effects compared to other measures

That vehicle traffic decreases as driving becomes more expensive is hardly surprising. An interesting question, however, is how great the effect of the Stockholm Trial is compared to other types of measures. The answer is that the reduction in traffic congestion and travel times is big compared to other measures which have been carried out or discussed in regard to Stockholm traffic. The following can be mentioned as examples:

- A new eastern connection between Nacka and the inner city (the so-called Österleden or Eastern bypass) is estimated to reduce the number of vehicles passing over inner-city bridges by approximately 14%. The equivalent reduction for a new Western bypass (bypassing the City of Stockholm) is estimated at 11%.

- The rise in the price of petrol by just under one krona (9%) which took place between April 2005 and April 2006 is estimated to have reduced traffic over the charge cordon by less than 3%.

- The zero tax on Stockholm’s public transport is estimated to reduce vehicle kilometres travelled – the total of distances covered – in Stockholm County by 3%.

It should also be remembered that road investments are expensive and roads take a long time to build. Many desirable investments in Stockholm fall into the several-billion-kronor class. For example, the Stockholm Bypass is estimated to cost SEK 20 billion and the Citybanan (a commuter-train tunnel) about SEK 14 billion. Since the congestion tax instead results in a surplus of SEK 500-600 million each year, after operational costs have been deducted, it is unreasonable to set these investments against the congestion tax, as if they were comparable substitutes for each other. Both financially and from a traffic perspective, it is more natural to see them as complements.

At the same time, it should be pointed out that the congestion tax – even if the net effect for society is positive – does mean sacrifices for many people. These sacrifices should be set against the positive accessibility and environmental effects that the congestion tax leads to.

The significance of the Stockholm Trial as such

The Stockholm Trial resulted in a unique collection of data about traffic and its effects in Stockholm. Knowledge and competence in this area therefore increased. We briefly present some of these lessons:

For example, we can now see that improvements in travel times are so tangible that they have been perceived by the general public, which has also expressed satisfaction with this improvement. A valuable lesson of the Stockholm Trial is also that travel-time improvements occurred far from the inner city. This was not previously known.
The 10% reduction in truck passages over the charge cordon was unexpected. For the future, it would have been valuable to be able to discuss in more detail what the commercial-traffic adjustments actually look like.

Many of us – though not all – were surprised that no more than about half of the motorists who “disappeared” were replaced by travellers using public transport instead. This is a sign that the number of trips is not a fixed number which can be divided into different destinations, modes of transport or times. Even though adjustment in travel-start times was seen in several studies, the substantially reduced number of vehicle journeys makes it clear that this adjustment strategy is of lesser significance. A further factor supporting this is the fact that Essingeleden has coped so well.

Adjustment to the congestion tax occurred and it took place quickly. Before the Stockholm Trial – and especially when it became clear that the trial period would be reduced to six months – there was some doubt as to whether the traffic reduction would actually take place. Would the trial be considered as something so brief and transient that it wasn’t worth changing behaviour, with people deciding instead to ‘sit out’ the trial period without adjusting travel habits? We now know that the Stockholm Trial had an immediate effect.

Since there is no direct effect to be seen on the retail market and the rest of the economy, the Stockholm Trial has revealed the possibility of reducing travel without influencing economic growth, so-called decoupling.

The Stockholm Trial provides interesting insights into what a road-toll system should look like – something which is also useful for other cities. Traffic economists have long discussed to what extent a charge-zone toll of the kind used in Stockholm is sufficient for controlling traffic in an entire city. Traffic relations change from street to street and from minute to minute. When the charge zone is as large as it is in Stockholm, there was concern that even if it had a big effect on travel over the charge cordon, streets inside the zone would soon be full of motorists already in the zone increasing travel as they realized the streets were less congested. Alternative solutions were discussed for several years prior to the Stockholm Trial, involving several sub-zones with varying rates of the congestion tax. None of the existing road-toll systems threw much light on this question. In London, it is a question of a small area in the city centre, in Singapore access to cars is also regulated and in Oslo and Bergen the system is designed to affect traffic as little as possible. The Stockholm Trial confirms that a simple charge-zone toll creates significant effects within a large area.

Prior to the possibility of the congestion tax becoming permanent, there is reason to discuss how the tax should be structured and differentiated. We believe, for example, that the charge period should be shortened somewhat in the mornings. There may also be reasons to consider whether tax levels should vary in relation to seasonal traffic variations. We have no definite answer to the question of whether it is desirable from a traffic perspective to make an exception of Essingeleden. Even though accessi-
bility has not significantly worsened during the Stockholm Trial period, increased traffic on this bypass means increased vulnerability to disturbances of the traffic system as a whole.

It is also clear that increased investment in public transport cannot alone be used as a means of reducing congestion. Investment in public transport does not appear to result in any measurable increase in public-transport travel or reduction in vehicle traffic, despite SL registering increased travel on its network. A well-functioning public-transport system is a prerequisite, however, for being able to manage the increasing number of public-transport passengers.

What can be changed if the congestion tax becomes permanent?

The structure of the system is influenced by what the main goals are – it is of great significance whether the primary aim is to reduce congestion or to reduce the effect of traffic on the environment. In the event of the congestion tax becoming permanent, goals for what is to be achieved in the short and long term should be carefully discussed and formulated. From a cost-benefit perspective, the congestion tax should primarily be treated as an instrument for dealing with congestion.

- The relatively simple congestion-tax structure with a charge cordon has not led to dramatic differences in goal achievement at different locations. Know-how is now available, however, that can be used if a more complex congestion-tax structure is introduced. From a traffic perspective, it would be desirable to be able to vary congestion-tax levels throughout the year. Traffic in May-June is significantly higher than in winter and then falls to a very low level in the summer. This means that the traffic reduction necessary for good accessibility varies throughout the year. This could be steered by varying congestion-tax levels throughout the year.

- The goal of a 10-15% reduction in traffic flow is probably at the lower end of what needs to be achieved for good accessibility at certain times and places. In May-June, when traffic is at its height, greater reductions than this are necessary to achieve really good accessibility.

- The total congestion-tax level, on the whole, has been adequate, or possibly more than adequate, to achieve desired effects.

- It is difficult to give any definite answer to the question of whether the congestion tax should be levied on Essingeleden traffic when the inner city is already subject to congestion tax. To date, accessibility has been relatively unchanged compared to last year but the traffic load is so high that accessibility is greatly affected even by small changes in traffic flow.
Congestion taxes can make Stockholm more attractive

For many cities, attractiveness is an important question for future development and survival. It has been said that the congestion tax negatively influences attractiveness but it is worth noting that serious congestion problems make it more difficult for businesses to operate, which reduces a city’s attractiveness.

In many larger cities around the world, congestion and environmental influences hinder continued sustainable city development. Congestion taxes are now discussed in a large number of European cities and many are closely watching developments in Stockholm. In the USA, it was recently decided at federal level to carry out a large number of trials using congestion taxes. In all these cases, the congestion tax is seen not only as a means of increasing accessibility but also as a means for cities to retain their attractiveness and develop for the benefit of citizens and business. As an example, it can be mentioned that Kathryn Wylde, president of a business association in New York called Partnership for New York City, said at the international conference “Voices on the Stockholm Trial” that business in New York believes a congestion tax is necessary for the city to continue to be attractive in a way that makes it possible for businesses to continue to develop.

Recent research shows that a city’s attractiveness is of great importance when seeking skilled personnel, who in turn attract companies and create growth. Seen in this perspective, the Stockholm Trial and a permanent congestion-tax system would increase Stockholm’s attractiveness.
Appendix 1

Presentation of the Expert Group’s members

Staffan Algers works as senior consultant at Transek AB and has a PhD from the Royal Institute of Technology. He is an internationally renowned researcher with long experience of developing and applying traffic-prognosis models. He has led several large model-development projects. Staffan is also an associate professor at the Royal Institute of Technology in the division of transport and localization analysis.

Karin Brundell-Freij works as university lecturer at the Engineering Faculty, Lund University, from where she has a PhD. In research, she has specialized in analysis of traffic demand and modelling, road-safety analysis and transport and the environment.

Jonas Eliasson works as an analyst and consultant at Transek AB and has a doctorate from the Royal Institute of Technology. His research has primarily been directed at evaluation studies, national economics, transport and land-usage models.

Cecilia Henriksson is managing director of Inregia AB, an analysis/strategy company. She holds a licenciate degree from Stockholm University. She has many years’ experience of carrying out investigations and statistical work on regional development and is a specialist in analysis and strategic consulting for the retail market.

Lars Hultkrantz is professor of national economics at Örebro University and scientific advisor to the Swedish Road and Transport Research Institute. He is also a member of the Royal Swedish Academy of Engineering Sciences.

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

Lena Nerhagen is a lecturer at Högskolan Dalarna and researcher at the Swedish National Road and Transport Research Institute. She has a doctorate from the University of Gothenburg and specializes in transport and environmental economics. Currently she is focusing on the health effects of transport-generated particles and how these can be evaluated.

Lena Smidfelt Rosqvist works as traffic investigator at Trivector Traffic AB and has a doctorate from Lund University. Her area of expertise is a combination of environmental and traffic planning as well as traffic evaluation. She is also programme manager of 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 4: 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.

Figure 4 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 5 below shows the distribution of traffic on the various approach roads to the inner city area of Stockholm.

Figure 5: 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.)

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 bypass the inner city area. The reduction in traffic from the west is slightly smaller.
Figure 6: Percentage decline in traffic on the approach roads to the Stockholm inner city area during the charge period (06.30–18.30).

Figure 6 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.

<table>
<thead>
<tr>
<th>Congestion charge zone</th>
<th>Morning peak (07.00-09.00)</th>
<th>Afternoon/evening peak (16.00-18.00)</th>
<th>Charge period (06.30-18.29)</th>
<th>Full 24 hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major inner city streets: e.g. Vallhallavägen, Strandvägen, St Eriksg, Hornsg, Folkungag, etc.</td>
<td>-7%</td>
<td>-10%</td>
<td>-10%</td>
<td>-7%</td>
</tr>
<tr>
<td>Smaller inner city streets: e.g. Norrlandsgatan, Lindhagensgatan, Scheelegatan, Katarinavägen, etc.</td>
<td>-8%</td>
<td>-13%</td>
<td>-10%</td>
<td>-8%</td>
</tr>
<tr>
<td>North-south axis/inner city through-routes: e.g. Söderledstunneln, Centralbron Bridge and Klarastrandsleden</td>
<td>-2%</td>
<td>-10%</td>
<td>-12%</td>
<td>-8%</td>
</tr>
<tr>
<td>Outer approach roads: e.g. Nynäsv, Solnav, Huddingebron, Stocksundsbron Bridge, etc.</td>
<td>-3%</td>
<td>-4%</td>
<td>-5%</td>
<td>-5%</td>
</tr>
<tr>
<td>Outer link roads: e.g. Bergshamravägen, Örbyleden, Magelungsvägen, etc.</td>
<td>4%</td>
<td>4%</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>Outer-city roads: e.g. Gamla Tyresöv, Skärholmsvägen, Lugnets Allé, Skälbyvägen, etc.</td>
<td>-5%</td>
<td>-4%</td>
<td>-5%</td>
<td>-5%</td>
</tr>
</tbody>
</table>

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 throughput 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 Eugeniatunneln 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 throughput of traffic improves.

Approach roads from the suburbs along Nynäsvägen, Solnavägen, Huddingevägen and Stockhundbron 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, Lugnerts 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.

<table>
<thead>
<tr>
<th>Location and Monitoring Point</th>
<th>Morning peak (07.00-09.00)</th>
<th>Afternoon/evening peak (16.00-18.00)</th>
<th>Charge period (06.30-18.29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Södertäljevägen (Solberga)</td>
<td>-1%</td>
<td>-3%</td>
<td>-3%</td>
</tr>
<tr>
<td>Södertäljevägen (Midsommarkransen)</td>
<td>-3%</td>
<td>-3%</td>
<td>-3%</td>
</tr>
<tr>
<td>Essingeleden (Gröndalsbron Bridge)</td>
<td>0%</td>
<td>4%</td>
<td>5%</td>
</tr>
<tr>
<td>Essingeleden (Hornsberg)</td>
<td>-5%</td>
<td>-5%</td>
<td>-1%</td>
</tr>
<tr>
<td>Uppsalavägen (Frösundabacke)</td>
<td>4%</td>
<td>3%</td>
<td>1%</td>
</tr>
<tr>
<td>Sickla Kanalbro Bridge</td>
<td>16%</td>
<td>19%</td>
<td>18%</td>
</tr>
<tr>
<td>Södra Länken</td>
<td>21%</td>
<td>12%</td>
<td>19%</td>
</tr>
<tr>
<td>Södra Länken towards Essingeleden</td>
<td>15%</td>
<td>23%</td>
<td>26%</td>
</tr>
</tbody>
</table>

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.

![Graph showing average traffic flow on Saturdays in 2006 and 2005 on different categories of road.](image)

*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.**

<table>
<thead>
<tr>
<th></th>
<th>Inner city</th>
<th>County</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peak periods</strong></td>
<td>-14%</td>
<td>-4%</td>
</tr>
<tr>
<td><strong>Full 24 hours</strong></td>
<td>-14%</td>
<td>-2%</td>
</tr>
</tbody>
</table>

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 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.

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.

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.
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 weekday.

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.

![Number of vehicle passages over the charge cordon during weekdays 06.00–19.00.](image)

*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 reduc-
tion 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

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, Bergshamralen, 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)

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

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

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

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 queueing.

**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 queueing.

**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-
fered 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.

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](image)

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

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

Figur 3. Translation

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 di-
rection 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 can-
celled 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 vehi-
cles in spring 2006, which is a decline by 3 percentage points compared
with spring 2005. Comparing modes of transport it is commuter passen-
gers 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. Bicycle

The effect of the Stockholm Trial on pedestrian and bicycle traffic has been studied to see if it has had an influence on the number of pedestrian and bicycle trips, and if so, what kind of influence. Some of the tested hypotheses were:

- Short car trips over the congestion-charge zone cordon will be replaced by travel by foot and bicycle.
- Increased travel on public transport will lead to more and longer feeder connections by foot and bicycle.
- An improved street environment will increase comfort and security, attracting more people to walk and bicycle.

Effects on pedestrian and bicycle traffic

As a basis for the analysis of pedestrian and bicycle travel, the following are available:

- Traffic counts from five approaches before (October 2005) and during (March 2006) the Stockholm Trial, including both walking and bicycling
- City of Stockholm bicycle counts (once a year in May/June since 2000)
- Travel pattern studies in Stockholm County before (September 2004) and during (March 2006) the Stockholm Trial
- Interviews with cyclists at four places in Stockholm’s city centre, before (August/September 2003) and during (April/May 2006) the Stockholm Trial

For this version of the report, only the traffic counts at the five approaches and the interviews with the cyclists were available.

It is not possible from the traffic counts to determine whether or not there has been an increase in pedestrian and bicycle traffic since road conditions at the time for the 2006 traffic count were still wintry.

The interviews with the cyclists show that:

- A majority of cyclists at the four places included in the study said they bicycle as much now (i.e. spring 2006) as the spring before.
- Slightly less than one out of ten said they bicycle more after the introduction of the congestion tax.
- Two out of ten cyclists agree to a great extent that there are fewer cars and four out of ten feel the traffic environment to a great or some extent is better.
- A majority of cyclists feel there is no difference in safety or accessibility or the number of conflicts with other road users. A small number feel the situation is worse and about as many feel there is an improvement.
The above findings indicate that cyclists experience the traffic environment as better because of the Stockholm Trial, which might attract more people to cycle.

The remaining studies will presumably be able to give a more reliable and detailed answer to the question of more bicycles and what kind of travel has been affected. The final version will show whether the hypotheses have been verified.
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.

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

*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.

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

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 within Stockholm county**

5.1 **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. 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.

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1 Source: Statistics Sweden
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.

5.2 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

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Before trial period with congestion tax</th>
<th>During trial period with congestion tax</th>
<th>Change</th>
<th>Hypothesis</th>
<th>Hypothesis confirmed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police-reported fatalities and personal injuries</td>
<td>1,087</td>
<td>1,044</td>
<td>Decrease not significant</td>
<td>Will decrease within the congestion-tax zone</td>
<td>No</td>
</tr>
<tr>
<td>Accidents involving rear-end collisions</td>
<td>162</td>
<td>184</td>
<td>Increase not significant</td>
<td>Will decrease</td>
<td>No</td>
</tr>
</tbody>
</table>

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

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

\(^1\) 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 (PM$_{10}$) and nitrogen oxides (NOx and NO$_2$), 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, PM$_{10}$, 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.

<table>
<thead>
<tr>
<th></th>
<th>Inner city:</th>
<th>City of Stockholm:</th>
<th>Greater Stock-</th>
<th>Stockholm*:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tons/year</td>
<td>per cent</td>
<td>tons/year</td>
<td>per cent</td>
</tr>
<tr>
<td>Nitrogen oxides. NOx</td>
<td>45</td>
<td>-8.5 %</td>
<td>47</td>
<td>-2.7 %</td>
</tr>
<tr>
<td>Carbon monoxide. CO</td>
<td>670</td>
<td>-14 %</td>
<td>710</td>
<td>-5.1 %</td>
</tr>
<tr>
<td>Particles. PM$_{10}$ total</td>
<td>21</td>
<td>-13 %</td>
<td>23</td>
<td>-3.4 %</td>
</tr>
<tr>
<td>“erosion particles”</td>
<td>19</td>
<td>-13 %</td>
<td>21</td>
<td>-3.3 %</td>
</tr>
<tr>
<td>“exhaust particles”</td>
<td>1.8</td>
<td>-12 %</td>
<td>1.8</td>
<td>-4.4 %</td>
</tr>
<tr>
<td>Volatile organic compounds .VOC benzene. C$_6$H$_6$</td>
<td>110</td>
<td>-14 %</td>
<td>120</td>
<td>-5.2 %</td>
</tr>
<tr>
<td>Carbon dioxide. CO$_2$</td>
<td>36,000</td>
<td>-13 %</td>
<td>38,000</td>
<td>-5.4 %</td>
</tr>
</tbody>
</table>

* 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 (NOx) are calculated to have decreased by at most 5-10 µg/m$^3$ (micrograms per cubic metre of air) and levels of particles, PM$_{10}$, by at most 2-3 µg/m$^3$. 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.
On Hornsgatan the levels of nitrogen oxides (NOx) 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 (NOx) 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, PM\textsubscript{10} 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 (NO\textsubscript{2}) by approximately 5-6\% and the levels of particles (PM\textsubscript{10}) by 7\%. The improvement is sufficient for the environmental quality standard for the annual median value for nitrogen dioxide, NO\textsubscript{2}, not to be exceeded on Norrlandsgatan. Here too the environmental quality standard is, however, exceeded as regards high daily median values both for particles, PM\textsubscript{10} 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, PM\textsubscript{10} is being exceeded.

On Valhallavägen (NW of Lidingövägen) the levels of nitrogen oxides (NO\textsubscript{x}) at street level are calculated to have fallen by 12\%, and the levels of nitrogen dioxide (NO\textsubscript{2}) and particles (PM\textsubscript{10}) by approximately 7-8\%. The improvement is not sufficient to meet the environmental quality standard for high daily median values of particles, PM\textsubscript{10}, 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/m\textsuperscript{3} (micrograms per cubic metre of air) for nitrogen oxides, NO\textsubscript{x}, and up to approximately 2 µg/m\textsuperscript{3} for particles, PM\textsubscript{10}. 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.
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, NOₓ, 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 Klarstrandsleden 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.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Time period</th>
<th>Without congestion charge</th>
<th></th>
<th></th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pass.car</td>
<td>LCV</td>
<td>HGV</td>
<td>Bus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0600-0900</td>
<td>318,689</td>
<td>49,238</td>
<td>12,406</td>
<td>7,366</td>
<td>387,699</td>
</tr>
<tr>
<td></td>
<td>0900-1500</td>
<td>584,455</td>
<td>105,466</td>
<td>30,028</td>
<td>12,451</td>
<td>732,400</td>
</tr>
<tr>
<td></td>
<td>1500-1800</td>
<td>393,950</td>
<td>50,743</td>
<td>6,920</td>
<td>9,687</td>
<td>461,300</td>
</tr>
<tr>
<td></td>
<td>1800-0600</td>
<td>546,258</td>
<td>38,630</td>
<td>6,640</td>
<td>12,072</td>
<td>603,600</td>
</tr>
<tr>
<td></td>
<td>0000-2400</td>
<td>1,843,352</td>
<td>244,077</td>
<td>55,994</td>
<td>41,576</td>
<td>2,185,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With congestion charge</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pass.car</td>
<td>LCV</td>
<td>HGV</td>
<td>Bus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0600-0900</td>
<td>257,761</td>
<td>40,665</td>
<td>11,847</td>
<td>9,926</td>
<td>320,200</td>
</tr>
<tr>
<td></td>
<td>0900-1500</td>
<td>474,255</td>
<td>92,538</td>
<td>27,396</td>
<td>14,611</td>
<td>608,800</td>
</tr>
<tr>
<td></td>
<td>1500-1800</td>
<td>319,960</td>
<td>40,943</td>
<td>6,445</td>
<td>11,752</td>
<td>379,100</td>
</tr>
<tr>
<td></td>
<td>1800-0600</td>
<td>486,627</td>
<td>33,412</td>
<td>5,928</td>
<td>12,934</td>
<td>538,900</td>
</tr>
<tr>
<td></td>
<td>0000-2400</td>
<td>1,538,603</td>
<td>207,558</td>
<td>51,616</td>
<td>49,223</td>
<td>1,847,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Difference in %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pass.car</td>
<td>LCV</td>
<td>HGV</td>
<td>Bus</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-19.1</td>
<td>-17.4</td>
<td>-4.5</td>
<td>34.8</td>
<td>-17.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-18.9</td>
<td>-12.3</td>
<td>-8.8</td>
<td>17.3</td>
<td>-16.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-18.8</td>
<td>-19.3</td>
<td>-6.9</td>
<td>21.3</td>
<td>-17.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-10.9</td>
<td>-13.5</td>
<td>-10.7</td>
<td>7.1</td>
<td>-10.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-16.5</td>
<td>-15.0</td>
<td>-7.8</td>
<td>18.4</td>
<td>-15.5</td>
<td></td>
</tr>
</tbody>
</table>

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\textsubscript{x}, on the move, so-called hot emission (grams of NO\textsubscript{x} per vehicle kilometre driven).

![Figure S1](image-url)

\textbf{Figure S1} \quad \textit{Percentage changes in emissions factors for NO\textsubscript{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\textsubscript{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\textsubscript{x} emissions, this results in a relative deterioration. A heavy truck produces on average 25 times greater NO\textsubscript{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\textsubscript{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](image)

**Figure S2** Percentage changes in NO\textsubscript{x} emissions compared with changes in traffic.

Figure S2 shows the change in the total emissions of NO\textsubscript{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\textsubscript{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\textsubscript{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 (PM$_{10}$) which also have a high emission factor in heavy vehicles. But for PM$_{10}$ 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 PM$_{10}$:** 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.

**CO$_2$ 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 VTI. 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

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2 Wiklund, 2006
reduction of approximately 40-50 kg PM$_{10}$ from the road surface in January to March, which corresponds to a reduction of 14%.

Brake and tyre wear contributes 20-30 mg PM$_{10}$ 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 PM$_{10}$ 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.

<table>
<thead>
<tr>
<th>County</th>
<th>Time period</th>
<th>Difference in %</th>
<th>Pass.car</th>
<th>LCV</th>
<th>HGV</th>
<th>Bus</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0600-0900</td>
<td>-2.93</td>
<td>-2.70</td>
<td>-2.70</td>
<td><strong>10.28</strong></td>
<td>-2.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0900-1500</td>
<td>-0.36</td>
<td>-0.12</td>
<td>-0.12</td>
<td><strong>13.20</strong></td>
<td>-0.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1500-1800</td>
<td>-1.79</td>
<td>-1.56</td>
<td>-1.56</td>
<td><strong>11.57</strong></td>
<td>-1.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1800-0600</td>
<td>-2.72</td>
<td>-2.49</td>
<td>-2.49</td>
<td><strong>10.51</strong></td>
<td>-2.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0000-2400</td>
<td>-1.81</td>
<td>-1.58</td>
<td>-1.58</td>
<td><strong>11.54</strong></td>
<td>-1.58</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 PM$_{10}$**: 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.

**CO$_2$ 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 PM$_{10}$ 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 gaps 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 station 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 3  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

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

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/collection 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 spending 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 spending 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 spending 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 7 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 Sweden as a whole, Jan 2005 – Apr 2006.*

![Trend graph](image)

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*

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.³

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.

³ 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.
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.
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 dif-
It is 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 8: 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

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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 get to our 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 2006\(^4\) 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.

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\(^4\) From 8 May to 17 May inclusive.
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.

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**

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

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 affects 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 disappear 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 does impact on household purchasing power and may therefore 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 incomes 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 well be different 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 (Järfalla, 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 resident 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.

The third component is the costs involved in producing and distributing information about the trial and in evaluating the results of the trial. 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.

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5 This is due to technical difficulties relating to the calculations.
6 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.7

Table 4: Social cost-benefits, in millions of SEK per year.

<table>
<thead>
<tr>
<th>(SEK million, per year)</th>
<th>Congestion tax</th>
<th>Increased bus traffic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shorter journey times</td>
<td>523</td>
<td>157</td>
<td>680</td>
</tr>
<tr>
<td>More predictable journey times</td>
<td>78</td>
<td>0</td>
<td>78</td>
</tr>
<tr>
<td>Change in mode of travel</td>
<td>-13</td>
<td>24</td>
<td>11</td>
</tr>
<tr>
<td>Congestion tax payments</td>
<td>-763</td>
<td>0</td>
<td>-763</td>
</tr>
<tr>
<td><strong>Total effect: road-users</strong></td>
<td><strong>-175</strong></td>
<td><strong>181</strong></td>
<td><strong>6</strong></td>
</tr>
<tr>
<td>Reduced climate gas emissions</td>
<td>64</td>
<td>0</td>
<td>64</td>
</tr>
<tr>
<td>Health and other environmental benefits</td>
<td>22</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>Improved traffic safety</td>
<td>125</td>
<td>0</td>
<td>125</td>
</tr>
<tr>
<td><strong>Total effect: other factors</strong></td>
<td><strong>211</strong></td>
<td><strong>0</strong></td>
<td><strong>211</strong></td>
</tr>
<tr>
<td>Congestion tax revenue</td>
<td>763</td>
<td>0</td>
<td>763</td>
</tr>
<tr>
<td>Public transport revenue</td>
<td>184</td>
<td>0</td>
<td>184</td>
</tr>
<tr>
<td>Fuel tax revenue</td>
<td>-53</td>
<td>0</td>
<td>-53</td>
</tr>
<tr>
<td>Wear and tear on infrastructure</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Maintaining public transport standards8</td>
<td>-64</td>
<td>0</td>
<td>-64</td>
</tr>
<tr>
<td><strong>Total public sector income and expenses excl. operating and investment costs</strong></td>
<td><strong>831</strong></td>
<td><strong>0</strong></td>
<td><strong>831</strong></td>
</tr>
<tr>
<td><strong>Total social cost-benefit surplus excl. operating and investment costs</strong>9</td>
<td><strong>867</strong></td>
<td><strong>181</strong></td>
<td><strong>1048</strong></td>
</tr>
</tbody>
</table>

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

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7 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.
8 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).
9 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). 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.

**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.

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10 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.

11 City of Stockholm Environmental and Health Administration (2006).
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 million\(^{12}\)), the cost for maintaining the same average standard of comfort on public transport\(^{13}\) 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 (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.

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\(^{12}\) Based on a rough estimate: Stockholm Transport’s own figures are not yet available.
\(^{13}\) 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.
Table 5. Costs and benefits during the Stockholm Trial (in SEK millions during the trial period)\(^{14}\).

\(\text{NB. The duration of the trial periods for the congestion tax and the expansion of bus traffic differ.}\)

<table>
<thead>
<tr>
<th>(SEK millions, during the trial period)</th>
<th>Congestion tax</th>
<th>Increased bus traffic</th>
<th>Total</th>
<th>Increased rail traffic/park-and-ride</th>
<th>Information and evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surplus of social benefits over costs (excl. operating and investment costs – see Table 4)</td>
<td>506</td>
<td>248</td>
<td>754</td>
<td>(not calculated)</td>
<td>(values n.a.)</td>
</tr>
<tr>
<td>Costs during trial excl. residual values</td>
<td>-1821</td>
<td>-582</td>
<td>-2403</td>
<td>-88</td>
<td>-210</td>
</tr>
<tr>
<td>Distortion and opportunity costs(^{15})</td>
<td>-708</td>
<td>-308</td>
<td>-1017</td>
<td>-47</td>
<td>-111</td>
</tr>
<tr>
<td><strong>Net social benefit of the Stockholm Trial</strong></td>
<td><strong>-2,023</strong></td>
<td><strong>-642</strong></td>
<td><strong>-2,666</strong></td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

The calculations suggest that the congestion charging system and the expanded bus traffic have cost society approximately SEK 3.4 billion\(^{16}\) 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.

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\(^{14}\) 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.

\(^{15}\) 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.

\(^{16}\) Of which SEK 2.3 billion is “visible” public expenditure and a further SEK 1 billion is distortion and opportunity costs.
Table 6. Costs and benefits if the Stockholm Trial were to be made permanent.

<table>
<thead>
<tr>
<th>(SEK millions, per year)</th>
<th>Congestion tax</th>
<th>Increased bus traffic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surplus of social benefits over costs (excl. operating and investment costs – see Table 4)</td>
<td>867</td>
<td>181</td>
<td>1,048</td>
</tr>
<tr>
<td>Operating costs</td>
<td>-220</td>
<td>-341</td>
<td>-561</td>
</tr>
<tr>
<td>Distortion and opportunity costs</td>
<td>118</td>
<td>-181</td>
<td>-62</td>
</tr>
<tr>
<td><strong>Net annual benefit for society if the Stockholm Trial is made permanent</strong></td>
<td>765</td>
<td>-341</td>
<td>424</td>
</tr>
</tbody>
</table>

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.\(^\text{17}\) 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 year,\(^\text{18}\) 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.

\(^{17}\) 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.

\(^{18}\) Including distortion and opportunity costs: SEK 341 m + SEK 181 m = SEK 522 m.
Table 7. Costs and benefits if the Stockholm Trial were to be made permanent.

<table>
<thead>
<tr>
<th>(SEK millions, per year)</th>
<th>Congestion tax</th>
<th>Increased bus traffic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surplus of social benefits over costs (excl. operating and investment costs – see Table 4)</td>
<td>867</td>
<td>181</td>
<td>1048</td>
</tr>
<tr>
<td>Operating costs</td>
<td>-220</td>
<td>-177</td>
<td>-397</td>
</tr>
<tr>
<td>Distortion and opportunity costs</td>
<td>118</td>
<td>-94</td>
<td>25</td>
</tr>
<tr>
<td>Depreciation costs for investments</td>
<td>-50</td>
<td>-3</td>
<td>-53</td>
</tr>
<tr>
<td>Distortion and opportunity costs</td>
<td>-26</td>
<td>-2</td>
<td>-28</td>
</tr>
<tr>
<td><strong>Net annual benefit for society incl. depreciation on investment costs</strong></td>
<td><strong>690</strong></td>
<td><strong>-95</strong></td>
<td><strong>595</strong></td>
</tr>
</tbody>
</table>

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. 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

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19 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 considerable 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 million 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.

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20 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.\footnote{Neither figure takes into account interest rates or traffic growth.}

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.
15. **Attitudes**

15.1 **Companies**

**Background**
There are approximately 83,000 companies in Stockholm County, of which about 90% are small businesses with fewer than 10 employees. 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.

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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.