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Cost-benefit analysis of the congestion charge in Gothenburg

Bachelor thesis
Department of Economics and Statistics
Spring 2014

Project paper with discussant - Economics 15HP (NEG300)

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Abstract

In 2013 a congestion charge was implemented in Gothenburg. The main goal of the charge is to co-finance the West Swedish package, a collection of infrastructural investments in the region. Implementing a congestion charge is a common policy instrument used in order to reduce different externalities associated with road transportation. By increasing the cost of driving, traffic volume decreases and different positive effects occur, such as reduced travel time as well as improved environmental and health benefits. By conducting a cost and benefit analysis these positive effects can be measured and compared with the associated costs of the charging system. In effect, a cost-benefit analysis can be used as a tool to measure the social benefits of a congestion charge.

Studies conducted in Stockholm and London show positive net benefits resulting from the congestion charges implemented in respective city. This thesis uses a cost-benefit analysis to evaluate the welfare effects of the congestion charge in Gothenburg in a similar way. The results show a positive net benefit for Gothenburg with the current toll charge when public transportation is excluded from the analysis. The sensitivity analysis show that when the charge increases from 13 SEK to 15 SEK the net benefits also increases.

Contents

1. Introduction

In 2013 Gothenburg city implemented a congestion charge in order to reduce congestion in central Gothenburg, improve the environment and finance the West Swedish Package. A congestion charge is a type of road pricing policy instrument which enables the policy makers to both manage negative externalities caused by congestion and get revenues for other infrastructural projects. A congestion charge causes changes in traffic, which creates effects such as improved travel time and time reliability, improved environment, and increased public transportation usage. These effects can in the long-term perspective be beneficial for the whole society.

The aim of this thesis is to evaluate if the congestion charge introduced in 2013 would be beneficial for the Gothenburg region in a 20 years perspective based on the short-term effects during the first year of the charge. By conducting a Cost-benefit analysis (CBA) this enables us to evaluate costs and benefits of the congestion charge in a 20 years perspective. The defined benefits in the study are 1) reduced travel time, 2) reduced emissions, 3) reduced traffic accidents and 4) reduced time uncertainty. And the defined costs are 1) the total investment costs of the project, 2) operational costs as well as 3) an increased subsidy to the public transportation. In the study we assume that the traffic change before and after the charge can solely be explained by the implementation of the congestion charge in Gothenburg. Also we consider the fact that the congestion changes in traffic have positive effects on travel time, environment and public transportation.

The study first begins by giving a background of the congestion charge in Sweden and Gothenburg followed by a section where we first discuss previous literature about road pricing in general and thereafter the effects of congestion charges in Stockholm and London. In the methodology section we give a brief introduction to the theory behind Cost and Benefit analysis followed by a definition of different factors involved in the study. We also define and discuss the data collected for the study. Finally, in the last section we present and discuss the results.

2. Background

2.1 Road pricing in Sweden

Sweden has implemented congestion charges in order to handle problems with congestion in two of Sweden's biggest cities, Stockholm (2007) and Gothenburg (2013). This type of policy instrument enables the government to control congestion and air quality caused by road transportation in urban areas. The revenues from the charges are often earmarked for regional infrastructure investments.

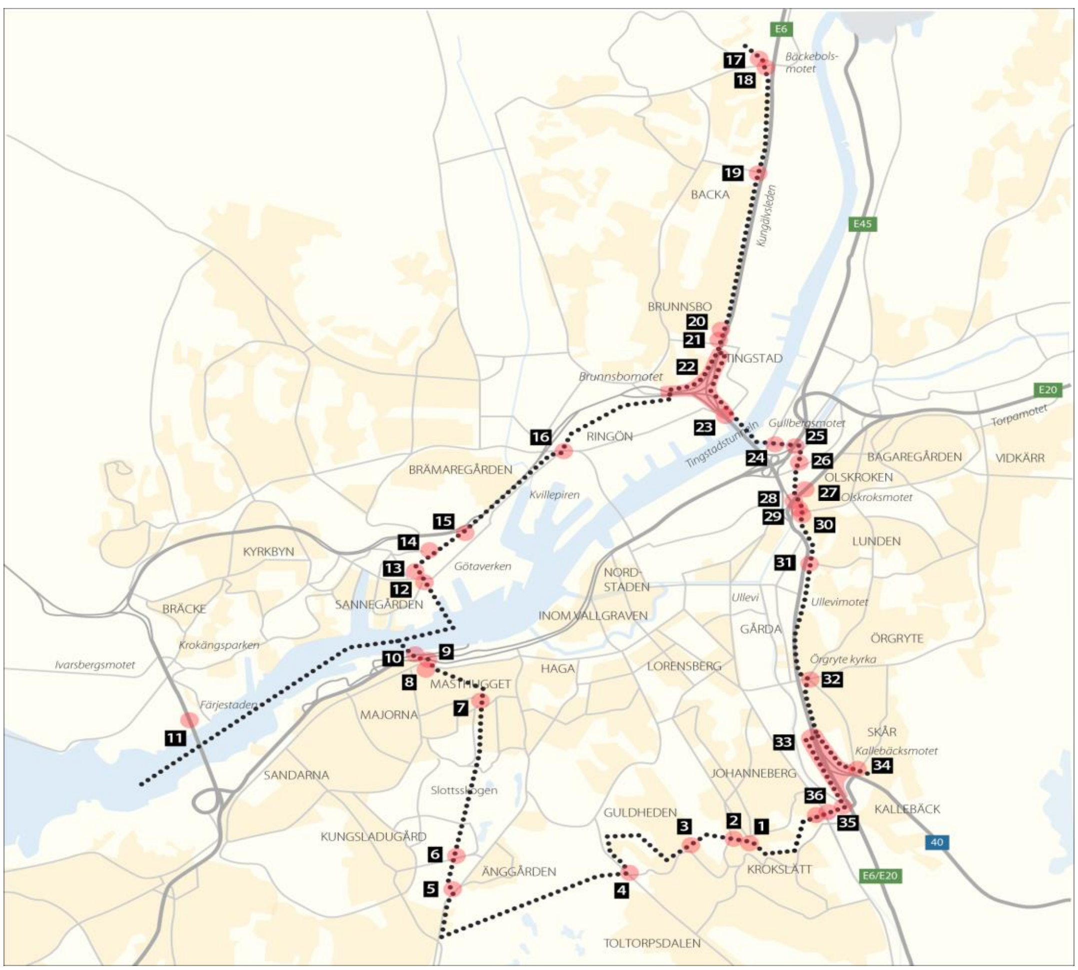
2.2 A congestion charge in Gothenburg

A congestion charge was implemented in January 2013 in Gothenburg. The reason for this implementation was firstly as a financing model for the West Swedish package (Transportstyrelsen (a)) and secondly to reduce congestion on road transportation and therefore reduce emissions and improve air quality. The system is basically the same as the system in Stockholm but with minor differences. For instance, there are 36 tollgates in Gothenburg compared to only 18 in Stockholm. The Gothenburg charging system is based on same structure with a cordon area in the central city but differ in some aspects due to population size and traffic volume. Since Gothenburg is surrounded by motorways, there is no way to get from the northern part of the city to the southern part without crossing a motorway, therefore the congestion is worst on the exits from the motorway. The charging system is constructed according to the congestion on these roads. The price of the charge is differentiated according to the peak hours when the congestion is at its highest point. In the mornings between 07.00 -07.59 and in the afternoon 15.30 - 16.59 the charge is 18 SEK and declines to 13 SEK and 8 SEK during non-rush hours (see figure 1). Due to the fact that many drivers in Gothenburg pass through multiple tollgates, the system has a multiple passage rule, which states that a vehicle can only be charged once if passing through several tollgates under 60 minutes. (Transportstyrelsen (a)).

Table 1: The time and the charge in Gothenburg in SEK.

Time	Charge from 1 January 2013	Charge from 1 of January 2015
06.00 - 06.29	8	10
06.30 - 06.59	13	15
07.00 - 07.59	18	20
08.00 - 08.29	13	15
08.30 - 14.59	8	10
15.00 - 15.29	13	15
15.30 - 16.59	18	20
17.00 - 17.59	13	15
18.00 - 18.29	8	10
18.30 - 05.59	0	0

Figure 1: Paying tolls in Gothenburg 2013 (Source Transportstyrelsen): The 36 paying tolls are placed according to the most congested passages in the central Gothenburg.



Source: Transportstyrelsen.

The charge applies weekdays between 06.00 and 18.29 and only to Swedish registered cars No charge is taken weekends, days before bigger holidays and in the summer period (July). The charges are going to be increased in 2015 from current levels to 10, 15 and 20 SEK. (Transportstyrelsen (b)).

As noted earlier one of the main reasons for the congestion charge is to co-finance the West Swedish package, a larger infrastructure project in order to meet the growing population in the region. The Gothenburg region is expanding; the population is estimated to grow from 1.8 million to 2 million until year 2025. Today only 25 % of the population in the region use the public transportation, the goal of the West Swedish package is to increase it to 40% by the year 2020. (Trafikverket (a)). The West Swedish Package contains five different goals, 1) creating opportunities for a larger labour market in the region, 2) creating a more attractive inner city region of Gothenburg, 3) a competitive public transportation system, 4) a good and healthy environment and 5) improve the quality of the industrial and commercial transportation in order to increase their international competitiveness. (Västsvenska paketet, 2011). Moreover, it contains 25 smaller and bigger infrastructure projects planned to the year 2025. The largest part of the package is an extension of the public transportation, containing projects such an underground commuting system, extension of existing bus lanes, trams systems etc. The whole package is estimated to a cost around 34 billion SEK, where 17 billion SEK is financed by the Swedish Government and 16 billion SEK is financed by revenues from the congestion charge, and the rest is financed from different regional partners. (Trafikverket (b)).

2.3 Literature review

2.3.1 Road pricing in theory

Road pricing is a common policy instrument used when faced with externalities caused by road transportation. Road pricing is an umbrella term for different kinds of policy instruments when dealing with road transportation externalities. In this study we refer to it as a congestion charge. Road transportation causes negative externalities when the cost of an externality is not internalized into the car drivers' private cost (illustrated in figure 2) of driving. This means that the car drivers do not take into consideration the social costs of driving and how road transportation affects other users of the road as well as people living in the surrounding area. Negative externalities can be for example; the costs of greenhouse gas emissions, air pollution and noise from the roads that affect both those using the road and people in the surrounding area. But also externalities (Anas & Lindsey, 2014) such as time delays because of congestion, extra fuel consumption, traffic accidents and infrastructural damages.

When faced with a congestion charge, the car drivers' private cost will increase, since it now includes the cost of the charge (illustrated in figure 3). Car drivers integrate the cost of congestion in their private cost which will close the gap between equilibrium (under charge) and the socially optimal solution on the road market. This implies changes in people's behaviour and adjustments in their trip frequency.

Figure 2: The demand for cars before the charge (toll).

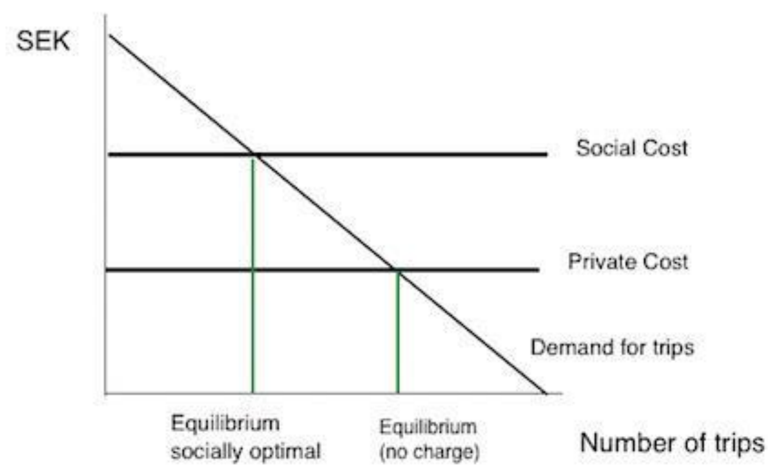
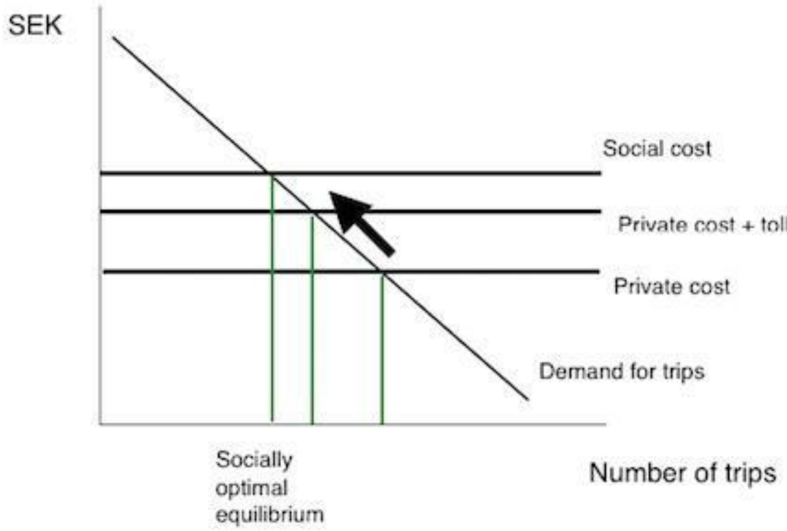


Figure 3: The demand for cars after introducing a charge (toll).



Studies from Stockholm (Eliasson, 2008) and London (Santos, 2008) show that people made adjustments in their trip frequency when faced with a charge. They made changes in their choice of destination, as well as in the time of the day they choose to travel. This happens because externalities can be corrected for by imposing a charge in accordance to the costs of the externality based on Pigous welfare economics theory (Anas & Lindsey, 2014). The charge forces the drivers to internalize the costs of congestion in their private cost and therefore eliminate the externalities. In recent years there has been an increase of this type of policy instrument to reduce congestion and improve air quality in cities such as Rome (2001), Durham (2002), London (2003), Stockholm (2006), Valletta (2007), Milan (2008) and Gothenburg (2013) (Eliasson, Börjesson, Hugosson and Brundell-Freij, 2012).

The effects are many, and they differ depending on conditions before and after the congestion charge is introduced but also if the implemented charge reflects the socially optimal charge on the market. One of main effects is a reduction in traffic which creates a series of effects such as decreased travel time, increased time reliability, decreased greenhouse emissions and increased public transportation. On an aggregated level an optimal charge can generate a social surplus for the whole society. However there is no guarantee that an implemented congestion charge will generate a social surplus. The effects depend on how the optimal level of the charge has been determined and under what conditions. Eliasson (2008) argues that the optimal level of the charge made by the policy makers may not always reflect the real charge. In this case the investments and operational costs may be higher than the social surplus making it possible to set a charge that is lower than what is considered as the socially optimal. This can result in a negative net present value (NPV) when conducting a (CBA). According to the same study (Eliasson, 2008) the design of the charging system is crucial for the policy to be optimal and generate a social surplus. Factors such as the physical, technical, political and informational restrictions can be crucial when designing a system but also factors such as public acceptability is of importance.

According to Eliasson (2008) the long-term effects of a charge can be smaller than the short-term effects for two reasons. The first explanation is that people after a while get accustomed to the charge, leaving them less concerned with the charge when making travelling decisions. This is called acclimation effect. In reality this can mean that people do not change their travelling behaviour regardless of the charge. The second effect relates to the freed-up road from introducing the charge. The charge reduces the travel time both in the cordon area and around it causing a situation where travellers with a higher value of time will in fact increase congestion rather than reduce it in the short-term, which happened in Stockholm during the trial period. But in a long-term perspective these effects will probably be smaller in both cases. At the same time the long-term effects can be larger than the short-term effects. The difference between short-term and long-term effects is that factors such as where people work and live as well as car ownership change in the long-term but not in short-term. In this case the effects are likely to be similar to the short-term effects but much larger (Eliasson, 2008).

2.4 Learning's from Stockholm and London

Congestion charges in Stockholm and London are two examples of how a charge can in fact reduce congestion and at the same time improve travel time and time reliability. Also it improves the environment in the region, resulting in a social surplus for the society. As noted before one of the main gains from a congestion charge is reduced traffic. This happened in both Stockholm and London after introducing a charge. The traffic was reduced by 21 % in the trial period (2006) in Stockholm (Eliasson, 2008) and by 30 % in

London (Santos, 2008) in the first year. The traffic reduction was larger when charges were first introduced in both cities and the effects wore off after a while but stabilized over a longer period of time. This, according to Eliasson (2012) can be explained by the acclimation effect, people getting accustomed to the charge leading to a situation where the charge is not a huge factor when making travelling arrangements. At the same time changes in traffic volume are affected by other external factors such as population growth, inflation and deductibility regulations. These factors are also of importance when trying to estimate the real traffic reduction.

The traffic reduction in Stockholm and London created a series of effects. In London, for instance, the travel time was reduced creating positive effects such as improved time reliability, improved environment and a higher usage of public transportation. One of the main objectives of the congestion charge in London was to reduce congestion but also to improve bus services and public transportation similar to the objectives of the congestion charge in Gothenburg. In London the effects were very clear that the reduced traffic had a positive effect on public transportation with an increase of 18 % in the number of bus passengers in the first year of the charge. This increase is explained both by the congestion charge but also by a decrease in the average paid bus fare (Santos, 2008).

There is always the possibility that the assumptions made will not hold and the traffic change will not have the coveted effects. One of the concerns with congestion charges is the risk of increased congestion on other links outside the cordon. This is based on the assumption that people will change their trip routes to links outside the cordon. There is always a risk of this but Eliasson (2012) estimates that these risks are relatively small when external factors such as population growth are accounted for. Studies from Stockholm showed a stable increase in the links outside the cordon (Södra länken and Essingeleden) but these have been stable over time and can partially be explained by population growth. The study also showed that car drivers with a higher value of travel time gained from these network effects, with higher time reliability. Due to limitations of this study network effects will not be taken into consideration in the present Cost-Benefit analysis.

A Cost-Benefit analysis (CBA) carried out in Stockholm by Eliasson (2008) based on the trial period 2006 showed a social surplus of 654 million SEK per year. The study was based on the assumption that the short-term effects during the trial period can be assumed to be the same in the long-term perspective of 20 years. In Stockholm the total investment cost (including the start-up cost, maintenance and operational costs) were 1.9 billion SEK and as estimated, it would be recovered in a 4.5-year period (based on 4 % discount rate). In the same CBA study two different scenarios were analysed, the first scenario was based on the assumption that benefits are constant over time whilst the second assumes a traffic growth of 1.5 % over time. Considering an annual maintenance and reinvestment cost of 220 million SEK, Eliasson (2008) estimated a Net present value (NPV) of 6.3 billion SEK for the first scenario (7.2 billion SEK for the second scenario) with a benefit/cost ratio of 2.5 (2.6) for the charge in Stockholm. The NPV proved to be different depending on the assumptions made about the traffic growth. In the Stockholm the CBA showed a social surplus for the society after the trial period. Even congestion charge in London proved to be beneficial for the city and region. Santos (2008) showed that the annual NPV in London was estimated to £122 million (at 2005 price levels) with a cost/benefit ratio of 2.27.

Congestion charge as a policy instrument can be beneficial for a city or region when constructed under the right conditions. More specifically, factors such as the design of the system are of importance and the conditions under which the charge was implemented. Another factor is the level to which the optimal charge reflects the real price.

3. Method

3.1 Cost-Benefit Analysis

A (CBA) is an economic method to analyse the costs and benefits of a project or investment. Normally these types of analysis are carried out before a project is chosen and implemented, but in Gothenburg the congestion charge was already implemented and running for a year before this CBA was conducted. (European Commission, 2008, p. 13). The analysis is therefore partly based on observed data. Since the aim of this CBA is to analyse if the congestion charge in Gothenburg is beneficial for the region in a long-term perspective, the economic analysis conducted will focus mainly on the social welfare of the region and not for the single owners of a project. The analysis includes only the direct effects of the charge, defined as effects within the transportation system and not indirect such as network effects on links outside the cordon or employment. Since these types of project lack market values the effects of reduced traffic volume can be obtained by monetization. In the sections Costs and Benefits below we show how different effects have been obtained and valued (European Commission, 2008, p. 47)[1]. These are based on previous research papers for example (Eliasson, 2008 and Danna et. al, 2012) conducting CBA on similar projects in Stockholm and Seattle. The time perspective is 20 years, a period used in similar research (Eliasson, 2008). The benefits and costs have been summed up for each year. Future values have then been discounted to calculate the net present value from introducing a congestion charge. The study is based on the assumption that the yearly benefits and costs will be the same for the whole time period of 20 years.

3.2 Data Collection

3.2.1 Traffic data

In order to conduct a CBA, data on variables such as traffic volume and traffic accidents are needed. The data regarding the traffic volume were collected from Trafikverket[2], measured

[1] The method applied in the present study, follows the Guide to Cost-benefit analysis of Investment projects published by the European Commission. (2008, p. 47).
[2] Data on traffic volume is not publicly available, but was provided to us by Trafikverket directly.

at the location of each tollgate. Since there is no way of entering the city without passing a tollgate, the total amount of traffic is captured.

Data on traffic accidents were collected from Trafikanalys. The data are divided in three different categories: (i) the number of killed from traffic accidents, (ii) major and (iii) minor injured in traffic accidents. (Trafikanalys olycksstatistik, 2012). The data is based on accidents reported to the police.

3.2.2 Public transportation

The change in public transport ridership is reported in the monthly reports of the West Swedish Package. The annual change from 2012 to 2013, as well as the total number of rides in the Gothenburg region is used. During 2013 public transport ridership increased by 10%. Following Eliasson (2008) we also assume that 1.5% of the increase in public transport usage is due to other factors than the congestion charge. Thus, the actual increase in public transport usage used in this thesis is 8.5%.

The subsidy per trip is calculated using data from the annual report of Västtrafik (2013). We calculate the subsidy per trip by dividing the total government subsidy by the total number of trips.

3.2.3 Emission data

The levels of NO_x in the air define the data on air quality and the measurements are based on the total NO_x tonne per year from road traffic, which were 2265 tonnes/year (based on 2012 levels) (Miljöförvaltningen, 2013). The human exposures of NO_x are estimated to decrease between 3 - 5 % in central Gothenburg according to Miljöförvalningens (2013) prediction. The greenhouse emission data are based on the average emission per car measured in g/km collected from Trafikverket (Trafikverket (e)), estimated to 172 g/km per car in 2012.

3.2.4 Costs

The investment (start-up costs), operational and maintenance costs were all collected from the Road Administration responsible for the West Swedish project. The investment costs include planning of the project, infrastructure, system, tests and operation start, training and information. The yearly operating costs are estimated to 117 million SEK.

3.2.5 Elasticities

Elasticity calculations are based on Danna et al's (2012) method in their CBA. Using the measured changes in traffic volume resulting from the congestion charging, the elasticity of demand for car travel in Gothenburg can be measured. The formula is given by Danna et al (2012):

$$\Delta Vehicle\ Trips = \varepsilon_p (\frac{Toll}{Trip\ Cost}) Vehicle\ Trips \rightarrow \varepsilon_p = \frac{\Delta Vehicle\ Trips}{(\frac{Toll}{Trip\ Cost}) Vehicle\ Trips}$$

Where ε_p is the price elasticity of vehicle trips, $\Delta Vehicle\ Trips$ is the change in vehicle trips between 2012 and 2013, $Toll$ is the average toll charge, $Trip\ Cost$ is the average cost per Scandinavian mile and $Vehicle\ Trips$ is the total number of vehicle trips before the congestion charge was implemented. Using data on the measured traffic change from the Swedish Road Administration, we can calculate the approximate elasticity of traffic change in Gothenburg. Data is collected on vehicle passages under the tollgates, which will be used as a proxy of vehicle trips in this study. The assumption that the change in traffic volume can be fully explained by the congestion charge alone is used.

$$\varepsilon_p = \frac{\Delta Vehicle\ Trips}{(\frac{Toll}{Trip\ Cost}) Vehicle\ Trips} = \varepsilon_p = \frac{-77\ 619}{(\frac{13}{31}) 769\ 031} = -0.697$$

We use a trip cost of 31 SEK/Scandinavian mile, which should reflect a good estimation of the average cost in Sweden. The elasticity for traffic volume change in Gothenburg is calculated to be -0.695 (see formula above). This implies that increasing the cost of driving by 10 % will lower vehicle trips by 6.9 %.

Calculating the elasticities for all variables dependent on the reduction in traffic volume has several benefits. When conducting sensitivity analysis, a new CBA can easily be calculated by changing the traffic volume reduction and calculating new changes based on the elasticities. Further down in this section a more thorough explanation of the elasticities follows.

Table 2: Traffic change after introducing the charge.

Traffic Change	
Traffic volume change[1]	-10.09% (Average toll of 13 SEK)
Traffic volume elasticity	-0.697
Change in vehicle trips (Daily average)[1]	-77 619
Total amount of vehicle trips (Daily average, 2012)[1]	769 031
Average toll[2]	13 SEK
Trip cost[3]	31 SEK/Scandinavian mile

1. Data on traffic volume is collected from Trafikverket.
2. Average toll is the average of the different road tolls.
3. Trip cost is estimated on the cost of driving a Volvo V70 (2008) that we assume is a good approximation of the average car in Sweden.

3.2.6 Discounting

When conducting a CBA, costs and benefits often incur in different time periods. To properly value these benefits and costs they are discounted to present values. Discounting is performed with the following formula:

$$PV = \frac{FV}{(1+r)^t}$$

Where PV is the present value, FV is the future value, r is the discount factor and t the future time period.

A discount rate of 4% is used in this thesis. 4% is considered customary in Sweden when discounting infrastructural projects according to Eliasson. (Eliasson, 2008).

The discounting factor used in a CBA has a very significant effect on the long term profitability. Over a long period, a lower discount rate increases profitability very much whereas a higher discount rate decreases it. It is therefore important to acknowledge that the discount rate used plays an important role in the results of this thesis.

3.2.7 Traffic growth

There might be reason to believe that traffic will grow over the course of the lifetime of the congestion charge. Eliasson (2008) uses an estimation of 1.5% traffic growth, letting both benefits and costs grow by the same percentage to compare with the no growth scenario. In this thesis, the same growth scenario will be analysed as well.

3.2.8 Sensitivity analysis

Since there is an uncertainty involved with the traffic flow in the future, a sensitivity analysis is performed regarding the change in traffic. The analysis is based on two different toll charges, the first is the current level of 13 SEK (on average) and the second is the planned increase to 15 SEK (on average) in 2015. In addition to this we create three different scenarios of traffic change, 1) no reduction in traffic, 2) a reduction in traffic based on the elasticity of traffic change (10.09% and 11.61% using a toll charge of 13 SEK and 15 SEK respectively) and 3) a 20 % reduction in traffic. The situation with and without taking into account the cost of the increase in public transport subsidy will also be analysed, since there is uncertainty regarding many aspects of the CBA. All scenarios are summarized in table 3 below. Doing a sensitivity analysis helps us to deal with uncertainty correlated with traffic flows in the future.

Table 3: Scenarios for the sensitivity analysis

Scenario	Assumptions
Scenario 1	Public transport subsidy included Toll charge of 13 SEK No traffic decrease
Scenario 2	Public transport subsidy included Toll charge of 13 SEK 10.09 % reduction in traffic
Scenario 3	Public transport subsidy included Toll charge of 13 SEK Traffic decrease of 20%
Scenario 4	Public transport subsidy included Toll charge of 15 SEK No traffic decrease
Scenario 5	Public transport subsidy included Toll charge of 15 SEK 11.61% reduction in traffic
Scenario 6	Public transport subsidy included Toll charge of 15 SEK Traffic decrease of 20%
Scenario 7	Public transport subsidy not included Toll charge of 13 SEK No traffic decrease
Scenario 8	Public transport subsidy not included Toll charge of 13 SEK

	10.09 % reduction in traffic
Scenario 9	Public transport subsidy not included Toll charge of 13 SEK Traffic decrease of 20%
Scenario 10	Public transport subsidy not included Toll charge of 15 SEK No traffic decrease
Scenario 11	Public transport subsidy not included Toll charge of 15 SEK 11.61% reduction in traffic
Scenario 12	Public transport subsidy not included Toll charge of 15 SEK Traffic decrease of 20%

3.3 Benefits

3.3.1 Lower travel time

Following Danna et al's (2012) method, using elasticities, a general reduction in travel times can be measured. The formula below describes the relationship between the reduction in travel time and traffic volume.

$$\Delta t = \epsilon_t(\%\Delta Trips) * t$$

Where Δt is the change in travel time, ϵ_t is the elasticity of the change in travel time related to a reduction in traffic volume, $\%\Delta Trips$ is the percentual reduction in traffic volume and t is the average travel time in Gothenburg[3].

The elasticity of change in travel time related to a change in traffic volume is taken from Danna et al (2012). This is possible under the assumption that same relationship exists between travel time and traffic volume in Gothenburg as in the cities investigated by Danna et al.

$$\Delta t = \epsilon_t(\%\Delta Trips) * t = \Delta t = 0.1471 * 10.06\% * 0.56 = 0.008277\ hours$$

[3] The average travel time for Gothenburg is not available publicly, but is taken from the *national travel habit research 2011-2012 (RVU 2011-2012). Travel time is based on the average travel time for people traveling by car to work with the destination inside the city of Gothenburg.*

By multiplying 0.008277 hours with the average value of time per vehicle and the total number of vehicle trips gives us the total time saving benefits from the congestion tax per year. Using the data on total amount of trips in Gothenburg, the yearly benefit of reduced travel time in Gothenburg can be calculated (see formula below).

$$Benefit_{Travel\ time} = t * Value_{time} * Passages =$$
$$= 0.008277 * 122 * 173\ 244\ 015 = 175\ 466\ 950.60\ SEK$$

Where $Benefit_{Travel\ time}$ is the monetary benefit from a reduction in travel time related to the congestion charge, t is the time saved per trip, $Value_{time}$ is the time value per trip and Passages is the total number of passages 2012 during weekdays.

The average value of time per vehicle is taken from Eliassons (2008) analysis of the Stockholm congestion charge. The value is derived from time value for private and goods traffic, number of passengers per car as well as the percentual mix of private and goods traffic. Even though the value is calculated for Stockholm, the difference should be small compared to Gothenburg and in this study we make the assumption that the value is a good estimate of the average value of time per vehicle in Gothenburg as well.

3.3.2 Travel time uncertainty

Reduced traffic volume also reduces the uncertainty regarding travel time. This means travellers need to budget less time for traveling, leading to an increased welfare for car users. Studies conducted by Danna et al. (2012) of the congestion charges implemented in London, Milan and Stockholm measures the benefits from a reduction in travel time uncertainty to be roughly a third of the benefits from reduced travel times. The economic benefits resulting from travel time uncertainty is therefore:

$$\frac{175\ 466\ 950{,}60\ \text{kr}}{3} = 58\ 488\ 983.53\ \text{SEK}$$

Table 3: Travel time after the charge.

Travel Time	Values	Economic values in SEK
Total number of passages 2012[1]	173 244 015	

Average travel time[2]	0.56 hours	
Elasticity[3]	0.1471	
Average value of time per vehicle[4]	122 SEK/h	
Value of time savings per year	-	175 466 950
Value of time uncertainty	-	58 488 983
Total economic value of Time	-	260 634 149

1. Data on total number of passages is collected from Trafikverket.
2. Travel time is the average work commuting distance taken from the national travel habit research 2011-2012 (RVU 2011-2012)
3. Elasticity is taken from Danna et al (2012)
4. Average value of time per vehicle is taken from Eliasson (2008)

3.3.3 Reduced emissions

A reduction in traffic inadvertently leads to a reduction in emissions associated with car usage. In this CBA we focus on the NO_x and CO_2 emissions. High levels of NO_x and CO_2 have both environmental and health-damaging aspects that can be considered as benefits when reduced. Assuming that the relationship between NO_x and CO_2 emissions and traffic change is the same for Gothenburg as it is for Stockholm and Seattle, enables us to use the elasticities derived by Danna et al (2012). Using the elasticities for both NO_x and CO_2 emissions, the percentual reduction in emissions can be calculated.

3.3.3.1 NO_x emissions

The reduction in NO_x emissions is given by the following formula:

$$\%\Delta NO_x = \varepsilon_{NO_x}(\%\Delta Traffic\ Volume) = 0.3571 * (-10.06\%) = -3.59\%$$

Where $\%\Delta NO_x$ is the percentual change in NO_x emissions, ε_{NO_x} is the elasticity of a change in NO_x emissions relating to a change in traffic volume and $\%\Delta Traffic\ Volume$ is the measured change in traffic volume. NO_x emissions are estimated to have decreased by 3.58 % in Gothenburg. The yearly benefits associated with reduced NO_x emissions is calculated to be 43 314 SEK per year. To estimate the economic value of NO_x emissions, the following formula has been used:

$$Economic\ value\ of\ reduced\ NO_x\ emissions\ =\ Previous\ level\ of\ NO_x * Cost_{NO_x} * \%\Delta NO_x =$$
$$= 2269 * 532.17 * 0.0359 = 43\,314.78\ SEK$$

3.3.3.2 CO2 emissions

The reduction in CO_2 relating to the reduction in traffic volume is given by the following formula:

$$\%\Delta CO_2 = \varepsilon_{CO2}(\%\Delta Traffic\ Volume) = \%\Delta CO_2 = 0.5042 * (-10.06\%) = -5.07\%$$

Where $\%\Delta CO_2$ is the percentual change in CO_2 emissions, ε_{CO2} is the elasticity of a change in CO_2 emissions relating to a change in traffic volume and $\%\Delta Traffic\ Volume$ is the measured change in traffic volume. The reduction in CO_2 emissions is estimated to be -5.07 % using Danna et al's (2012) method. Since there was no available data on previous levels of CO_2 in Gothenburg, the estimation has been made based on the traffic volume and average CO_2 emissions per car (g/km) from the Trafikverket (Trafikverket (c)). The formula below is used to estimate the reduction in CO_2 emissions.

$$Emissions_{CO_2} = Traffic * Distance * Emission_{car} =$$
$$= 173\ 244\ 015 * 28.96 * 178 = 893\ 052\ 108.04$$

Where $Emissions_{CO_2}$ is previous emissions related to car traffic, $Traffic$ is the total number of passages 2012, Distance is the average work commuting distance (measured in Scandinavian miles) to Gothenburg and $Emission_{car}$ is the average CO_2 emissions from a Swedish car. An economic value has been estimated by the following formula:

$$Economic\ value\ of\ reduced\ CO_2 = (Emissions_{CO_2} * Cost_{CO_2}) * \%\Delta CO2 =$$
$$= 893\ 052\ 108.04 * 0.33 * 0.0509 = 14\ 997\ 431$$

Where $Economic\ value\ of\ reduced\ CO_2$ is the economic value of a reduction in CO_2 emissions related to a reduction in traffic volume due to the congestion charge, $Emissions_{CO_2}$ is the previous amount of emissions from traffic before the implementation of the congestion charge, $Cost_{CO_2}$ is the cost of a kilo of CO_2 emissions and $\%\Delta CO_2$ is the percentual reduction in CO_2 emissions related to the congestion charge. The yearly benefits related to a reduction in CO_2 emissions are estimated to be roughly 15 million SEK per year.

Table 4: A summary of the reduction in NOx and CO_2 emissions after the charge.

Nox Emissions	Values	CO_2 Emissions	Values
Total NO_x tonne/year from car traffic in Gothenburg (2011)[1]	2269	CO_2 average emission per car in g/km (2012)	178
Elasticity of NO_x emissions relating to traffic change[2]	0.3571	Elasticity of CO_2 emissions relating to traffic change[2]	0.5042
Estimated reduction in NO_x emissions (yearly)	-3.58 %	Estimated reduction in CO_2 emissions (yearly)	-5.09 %
Cost of NO_x per tonne (estimated)[3]	532 SEK	Environmental cost of CO_2 per Kg[4]	0.33 SEK
		Total CO_2 emissions originally [5]	893 052 108.04 Kg
Economic value of reduced NO_x emissions	**43 314 SEK**	**Economic value of reduced CO_2 emissions**	**14 997 431 SEK**

1. Data on total NO_x is collected from Miljöförvaltning report on air quality (2013).
2. Elasticities are taken from Danna et al (2012).
3. Cost of NO_x is taken from Danna et al (2012).
4. Cost of CO_2 is based on estimations of the CO_2 cost from different reports.
5. The total CO_2 emissions are calculated based on the total amount of trips and the average work commuting distance in Gothenburg.

Reduced emissions are closely correlated with improved health effects and we can assume that a reduction in emission will improve the human health in Gothenburg. In Eliassons (2008) paper health effects of a reduction in emissions is around one third of the total economic value of the reduction in emissions. We make the assumption that the same relationship holds for Gothenburg. In order to calculate the economic value of the health effects we use the following formula.

$$\textit{Economic value of health effects} = \textit{Total emission reduction}/3 =$$

$$= \frac{14\,997\,431}{3} = 4\,999\,143.89\ \ SEK$$

Where the *Economic value of health effects* is divided by 3 in order to estimate one third of the total reduction, estimated to be roughly 5 million SEK in Gothenburg.

3.3.4 Reduction of traffic Accidents

To calculate the economic value of reduced traffic accidents, the elasticity for accident reduction from Danna et al (2012) is used. Assuming the same relationship holds for Gothenburg, the change in traffic accidents resulting from the change in traffic volume can be calculated using this formula:

$$\%\Delta Traffic\ accidents = \varepsilon_{Traffic\ accidents}(\%\Delta Traffic\ Volume) =$$
$$= 0.15 * 0.1006 = -1.52\%$$

Where $\%\Delta Traffic\ accidents$ is the change in traffic accidents, $\varepsilon_{Traffic\ accidents}$ is the elasticity of change in traffic accidents resulting from a change in traffic volume and $\%\Delta Traffic\ Volume$ is the percentual change in traffic volume. Using the economical value of different kinds of accidents, taken from Eliasson (2008) together with the estimated change in traffic accidents as well as data on accidents for 2012, the yearly benefits resulting from higher traffic security can be calculated.

$$Economic\ value\ of\ reduced\ traffic\ accidents =$$
$$= \%\Delta Accidents * Injuries_{Minor} * Value_{minor} + \%\Delta Accidents * Injuries_{Major} * Value_{Major}$$
$$+ \%\Delta Accidents * Injuries_{Deadly} * Value_{Deadly}$$
$$= Economic\ value\ of\ reduced\ traffic\ accidents$$
$$= 0.0152 * (1245 * 170000 + 65 * 3100000 + 4 * 17500000) = 7\ 356\ 115.91\ SEK$$

Where $\%\Delta Accidents$ is the change in traffic accidents, $Injuries_{Minor}$, $Injuries_{Major}$ and $Injuries_{Deadly}$are the number of accidents with minor, major and deadly outcomes 2012 and $Value_{minor}$, $Value_{Major}$ and $Value_{Deadly}$is the economic value of each kind of accident. The yearly benefits resulting from a lower amount of accidents are estimated to be 7.3 million SEK per year.

Table 5: Change in traffic accidents after the charge.

Traffic accidents	Values	Economical values of different injuries (in SEK)
Elasticity[1]	0.15	-
Change (-10.06% change in traffic volume)	-1.52%	-
Minor injuries 2012[2]	1245	-
Major injuries 2012[2]	65	-
Deaths 2012[2]	4	-
Minor injury[3]		170 000
Major injury[3]		3 100 000

Death[3]	17 500 000
Economic value of reduced traffic accidents	**7 356 115**

1. The elasticity is taken from Danna et al (2012)
2. Accident data is from the Trafikanalys olycksstatistik (2012).
3. Economic values from Eliasson (2008)

3.4 Costs

3.4.1 Investment and operational costs

Investments cost are defined as all initial costs associated with the project, such as project planning, infrastructure, data system, education, information etc. The operational costs are costs associated with the maintenances of the system, basically the yearly costs, which are estimated to 117 million SEK. A summary of all the costs related to the project is presented in table 6.

Table 6: Project costs for the charging system in Gothenburg (in SEK).

The project	Investment costs
Project manager	-39 090 000
Infrastructure	-141 985 000
Roadside	-216 052 000
Central system	-339 320 000
Test and operation start	-11 338 000
Information and training/education	-13 162 000
TOTAL	**-760 947 000**
Tax effects	-228 284 100

Data on investment costs are collected from Trafikverket, the data is not publically available.

3.4.2 Consumer surplus

The toll paid by car users should be considered a loss of consumer surplus, since they now have to pay for something they didn't before. Therefore the total toll revenue collected is also the total loss of consumer surplus for car users, which is – 801 million SEK.

3.4.3 Marginal cost of public funds

In the CBA of the Stockholm trials, Eliasson (2008) states that it is customary in Sweden to multiply the net public expenditure with the marginal cost of public funds (MCPF). The reason is that the project needs to be scaled because it is financed by taxes that have a distortionary effect. Eliasson includes the following in the public expenditures of the project: revenue from the congestion charge, operating costs, the increase in public transit fares, the increase in public transport operating costs and decreased fuel tax revenues. The sum should then be multiplied with the MCPF that is stated to be 1.3 in Sweden. Because of a lack of data, loss of fuel tax revenue will not be included in the analysis.

3.4.3.1 Public transport

Since some people will switch from car to public transportation and public transport is subsidised by the local government in Gothenburg, the extra subsidy to the public transportation that can be related to the congestion charge needs to be included in the marginal cost of public funds. Public transportation in Gothenburg is owned by the government and therefore partially financed by governmental subsidies.

In this study we do a sensitivity analysis on public transportation by including two different scenarios in the CBA, in the first we do not include the effects from public transportation and in the second we include the effects of public transportation. The reason for this is that there is some uncertainty to what the long-term effect is on the public subsidy. Since the estimate of the extra subsidy is solely based on data from 2013, this estimate might not reflect the true value of the extra subsidy in the long-term. Since data exists on the change in public transport the elasticity can be calculated with the following formula:

$$\varepsilon_{Public\ transport} = \frac{\%\Delta Public\ transport}{\%\Delta Traffic} = \varepsilon_{Public\ transport} = \frac{8.50\%}{-10.09\%} = -0.84$$

Where $\varepsilon_{Public\ transport}$is the elasticity of change in public transport usage relating to a change in traffic volume, $\%\Delta Public\ transport$ is the percentual change in public transport usage and $\%\Delta Traffic$ is the percentual change in traffic volume. Since data already exists on the change in public transport usage, the elasticity will only be used in the sensitivity analysis when the different scenarios in traffic change will be evaluated.

To calculate the extra governmental subsidy resulting from increased public transport usage, and average subsidy per trip needs to be calculated. Using figures from the annual report of Västtrafik (2013), the public transport provider in Gothenburg, this average value can be calculated using this formula:

$$Subsidy_{trip} = \frac{Subsidy_{total\ 2013}}{Trips_{total}} = \frac{3\ 322\ 692\ 000}{283\ 000\ 000} = 11.74\ SEK\ per\ trip$$

Where $Subsidy_{trip}$ is the average governmental subsidy per public transport trip, $Subsidy_{total\ 2013}$ is the total government subsidy to Västtrafik 2013, $Trips_{total}$ is the total number of public transport trips by Västtrafik 2013.

With the average subsidy per trip calculated, the total cost of extra government subsidy to public transportation related to the congestion charge can be calculated.

$$Subsidy = Subsidy_{trip} * Trips_{Gothenburg\ 2012} * \%\Delta Public\ transport =$$
$$= 11.74 * 217\ 454\ 545 * 8.50\% = 217\ 081\ 698{,}03\ SEK$$

Where $Subsidy$ is the governmental subsidy due to the increase in public transport usage related to the congestion charge, $Subsidy_{trip}$is the average subsidy per trip, $Trips_{Gothenburg\ 2012}$is the number of public transport trips in Gothenburg before the implementation of the congestion charge and $\%\Delta Public\ transport$ is the change in public transportation related to the congestion charge.

Table 7: Governmental subsidy to public transportation in Gothenburg

Government subsidy to public transportation	Values
Elasticity	-0.84
Change[1]	8.50%
Subsidy per trip[2]	-11.74 SEK
Trips (Gothenburg 2012)[1]	217 454 545
Trips (Region 2013)	283 000 000
Government subsidy (2013)	217 081 698 SEK

1. Data collected from Trafikverket (Trafikverket (d)).
2. Calculated with data from the annual financial report of Västtrafik 2013.

3.4.3.2 Toll revenue

The toll revenue was 801 million SEK for 2013 according to the Trafikverket (Trafikverket (d)). When doing the sensitivity analysis a method is needed to calculate new toll revenue depending on changes in traffic. To do this, an average charge per passage is calculated based on the report of the annual results of the congestion charge for 2013. The effect on the net present value can also be calculated for different levels of toll charge with the same method. By dividing the toll revenue by the amount of tollgate passages the average charge can be found:

$$Charge_{average} = \frac{Toll\ revenue}{Passages} = \frac{801\ 000\ 000}{131\ 500\ 000} = 6.09\ SEK$$

Where $Charge_{average}$ is the average charge per passage, $Toll\ revenue$ is the total toll revenue for 2013 and $Passages$ are the total amount of passages during the charge period 2013.

Table 8: Toll revenue and number of passages during 2013.

Toll revenue	
Toll charge per passage	6.06 SEK
Toll passages during the congestion charge period 2013[1]	131 500 000
Toll revenue 2013[1]	801 000 000 SEK

Toll revenue and tollgate passages are collected from the Trafikverket (d).

3.4.3.3 Marginal cost of public funds

Table 9: Summary for marginal cost of public funds in SEK.

Marginal cost of public funds	
Toll revenue	801 000 000
Government subsidy to public transportation	-217 081 698
Operational costs	-117 000 000
Net public expenditure	**466 918 301**
Tax effects	140 075 490
Summary	**606 993 795**

4. Results

4.1 Cost-Benefit analysis

Table 10 contains a summary of the estimated costs and benefits from the congestion charge. As discussed earlier, the reduction in travel time seems to be the highest benefit associated with the congestion charge.

Table 10: Summary of the yearly Costs and Benefits in SEK.

Consumer surplus	**Monetary Value**
Reduced travel time	175 466 950
Time uncertainty	58 488 983
Paid congestion charge	-801 000 000
Consumer surplus total	**-567 044 065**
Externalities	
Reduced traffic accidents	7 356 115
CO2 emissions	14 997 432
NO emissions	43 444
Health effects	4 999 144
Externalities total	**27 418 114**
Government costs and revenues	
Toll revenue	801 000 000
Government subsidy	-217 081 698
Operational costs for charging system	-117 000 000
Government costs and revenues total	**466 918 301**
Tax effects	
Marginal cost of public funds	140 075 490
Social welfare	67 367 842
Net social benefit, excluding investment cost	

Table 11 shows the results of the net present benefits and costs according to different growth assumptions. If we assume that there will be no traffic growth the net present value is estimated to approximately -73.7 million SEK. If we instead assume there a traffic growth of 1.5 % the NPV will increase to 1 billion SEK.

Table 11: Summary of the Cost and Benefits analysis in SEK.

Cost-Benefit Analysis	Present benefits	Present costs	NPV
No growth	3 552 158 618	-3 625 838 764	-73 680 146
1.5 % traffic growth	4 088 858 781	-3 034 976 069	1 053 882 713

4.2 Sensitivity analysis

Sensitivity analysis conducted in this study is based on twelve different scenarios, where traffic volume, toll charge and public transport costs varies. Table 12 and13 presents the results from the sensitivity analysis.

In short, the NPV increases with a higher reduction in traffic volume and with a higher toll charge of 15 SEK. The same is true when we do not consider the expenditures relating to the public transportation system.

Table 12: Sensitivity analysis with public transportation and without traffic growth.

Scenario (Toll charge 13 SEK current)	Net present value	Scenario (Toll charge of 15 SEK from 2015)	Net present value
No reduction in traffic	576 053 708	No reduction in traffic	1 057 325 225
10.09 % reduction in traffic	-73 680 146	11.61 % reduction in traffic	265 456 687
20% reduction in traffic	-711 431 300	20 % reduction in traffic	-326 414 086

Table 13: Sensitivity analysis without public transportation and traffic growth.

With public transport Scenario (Toll charge 13 SEK current)	Net Present Value	Scenario (Toll charge of 15 SEK from 2015)	Net present value
No reduction in traffic	576 053 708	No reduction in traffic	1 057 325 225,06
10.09 % reduction in traffic	3 761 594 310	11.61 % reduction in traffic	4 608 886 039
20% reduction in traffic	6 888 385 661	20 % reduction in traffic	7 273 402 875

5. Discussion

5.1 Results

One of the most important parts of a CBA on congestion charges is the benefits resulting from travel time reduction. Since travel time reductions can amount to very high monetary benefits, the result of the CBA analysis often depends on the method used to evaluate the reduction in travel time. Our calculations of travel time reductions amount to 175 million SEK per year. If compared with CBA conducted in Stockholm (Eliasson, 2008), we find the benefits of travel time to be reasonable since Stockholm and Gothenburg are both major cities in Sweden with similar variables. Eliasson (2008) found that the reduction in travel time to be valued to 536 million SEK per year in Stockholm. Considering Gothenburg is smaller and had a lower congestion to begin with than Stockholm, the reduction in traffic volume shown to be about half (10 % reduction compared to 20 % reduction) of that in Stockholm, which seems to be a reasonable result. In particular the traffic reduction in Gothenburg is much lower when compared to both Stockholm (20%) and London (30%).

Even though the reduced traffic was half of the reduction in Stockholm the results shows a negative net present value of -73.7 million SEK with the assumption of no traffic growth in a 20 years perspective, and 1 billion SEK when we assume a traffic growth of 1.5 %. It is reasonable to assume that in the long-term perspective the traffic will grow with the addition of new traffic. Compare these results with Stockholm where Eliasson (2008) find a NPV of 6.3 billion SEK with no traffic growth and 7.6 billion SEK when 1.5 % traffic growth was assumed.

The net present value of the congestion charge in Gothenburg is much lower than what Eliasson (2008) and Danna et al. (2012) estimated for Stockholm and Seattle respectively. We have found some different reasons for these results. First of all, the elasticity for traffic reduction is lower in Gothenburg than what Danna et al (2012) estimated from similar projects in other cities. This means that for some reason car drivers in Gothenburg are more reluctant to switch from driving to other means of transportation. This results in lower values for time saved, one of the major social benefits of congestion pricing. Secondly, the measured increase in public transport usage in Gothenburg was 10 %. This is higher than the 6 % Eliasson (2008) states in Stockholm even though the traffic volume reduction was roughly half of that in Stockholm. This means the welfare effect will be lower in Gothenburg compared to Stockholm since public transport usage is quite costly, while the positive welfare effects will be lower.

In order to test the uncertainty in the CBA, a sensitivity analysis was conducted on different scenarios. The analysis showed that when we included public transportation in the analysis the NPV with the current toll charge was estimated to -73.7 million SEK and 256.5 million SEK with an increased toll charge (see table 12 for summary of the analysis). This can be compared with the scenario without public transportation, where the NPV was estimated to 3.8 billion SEK and 4.6 billion SEK respectively. These results show that when we exclude public transportation from the analysis the NPV increases drastically. This is important because comparing the cost of increased public transportation in this study with Eliassons (2008) result indicates that the cost of public transportation in this study might be too high. Eliasson assumes the cost of increased public transport capacity to be 64 million SEK, nearly a fourth of the 217 million SEK assumed in this study. Since the increased cost of public transportation amounts to a relatively high cost, the results of the sensitivity analysis helps us evaluate the uncertainty with regards to the true cost of public transportation.

In the sensitivity analysis we also tested the uncertainty by assuming different toll charges and different levels of traffic reduction. Results (see table 12) show that when the toll charge was increased to 15 SEK (which is a planned increase from 2015) the NPV increases in all different traffic scenarios compared with the current situation (when the toll charge is 13 SEK). This can be an indication that the current toll charge is not the socially optimal level, meaning that the price of the charge does not reflect the real market price, which could explain the relatively lower NPV.

There are most likely effects from the congestion charge that haven't been discussed in this thesis. The reason for omitting them is either that we are unaware of them or that they are too difficult to estimate for us to include them in this thesis. However, some effects deserve a mention since they have the potential to be very important in evaluating the congestion charge.

One important benefit resulting from the charge is the lowered travel time for public transport users in addition to car users. Since buses travel the same roads as the cars, it is reasonable to assume that time savings will occur for public transportation as well. A second important benefit is the welfare gain from previous public transport users thanks to the influx of new public transport riders. It is reasonable that a larger user base will increase public transport capacity, making it more convenient for existing users as well. This effect is probably offset somewhat by increased crowding on existing capacity as well. These effects may or may not be quite substantial in the long-term, but the effects are too difficult for us to measure and are also omitted in the analyses by Danna et al (2012) and Eliasson (2008).

A higher usage of public transportation could also be beneficial for the Gothenburg region in other ways that are hard to measure. For instance, regional growth and such are highly affected by a more advanced and more covering public transportation network, which can increase regional growth. At the same time the congestion charge enable the necessary infrastructure investments, which otherwise would result in higher taxes.

5.2 Data

One of the major limitations of this paper is uncertainty regarding data, especially data regarding number of cars. Since passages are measured, and one car can pass through many toll gates, there is uncertainty when calculating variables such as time value and CO_2 emissions. We make the assumption that the cars that pass through multiple tollgates, effectively passing through Gothenburg on their way to their destination, probably have a higher travel time and distance than the average used in this analysis. We therefore assume the number of passages to be a useful figure in this analysis. However, this is something that needs to be taken into account when evaluating the results of the analysis.

Almost all of the effects from the congestion charge in the analysis are based on measurements of expected results taken from the literature. A more complete and advanced analysis can probably use data taken from real life to further increase the accuracy of the analysis. This was however beyond the scope of our thesis.

6. Appendix

	Year 0	Year 1	Year 2	Year 3	Year 4 ...	Year 20
Consumer surplus						
Toll payment	-	- 801	- 801	- 801	- 801	- 801
Travel time reduction	-	175.4	175.4	175.4	175.4	175.4
Travel time uncertainty	-	58.4	58.4	58.4	58.4	58.4
Summary	-	**- 567**	**- 567**	**- 567**	**- 567**	**- 567**
Externalities						
Traffic accidents	-	7.3	7.3	7.3	7.3	7.3
CO2 emissions	-	15	15	15	15	15
NO emissions		0.043	0.043	0.043	0.043	0.043
Health effects		5	5	5	5	5
Summary		27.4	**27.4**	**27.4**	**27.4**	**27.4**
Public funds						
Toll Revenue		801	801	801	801	801
Management costs		- 117	- 117	- 117	- 117	- 117
Public transport costs		- 217	- 217	- 217	- 217	- 217
Investment costs	- 760.9	-	-	-	-	-
Summary	- 760.9	**466.9**	**466.9**	**466.9**	**466.9**	**466.9**
Tax effects						
Marginal cost of public funds	- 228.2	140	140	140	140	140
Social Welfare						
Social welfare	- 989.2	67.4	67.4	67.4	67.4	67.4
Present value	- 989.2	64.8	62.3	59.9	57.6	30.7
	Total					
Net present value	-73.7					

7. References

Anas Alex, Lindsey Robin (2011). Reducing Urban Road Transportation Externalities: Road Pricing in Theory and Practice. *Review of Environmental Economics and Policy,* Volume 5 issue 1, 66-88.

Eliasson Jonas (2008). A Cost-Benefit Analysis of the Stockholm congestion charging system. *Transportation Research Part A,* 43, 468 - 480.

Eliasson Jonas, Börjesson Maria, Hugosson Muriel, Brundell-Freij Karin (2012). Stockholm congestion charge - 5 years on. Effects, acceptability and lessons learnt. *Transport policy,* 20(2012), 1 - 12.

European Comission (2008). *Guide to Cost Benefit analysis of Investment Projects*. European Union: Regional Policy.

Miljöförvaltningen, *Luftkvalitet i Göteborgsområdet: Årsrapport 2012*, 2012, Göteborgs stad.

Miljöförvaltningen, *Trängselskattens effekter på luftkvalitet i Göteborgsområdet*, 2013, Göteborgs stad.

Santos Georgina (2008). London Congestion Charging. *Brooking-Whartons paper on Urban Affairs,* 177 - 234.

Steven Danna, Keibun Mori, Jake Vela & Michelle Ward (2012). *A Benefit-Cost Analysis of Road Pricing in Downtown Seattle,* The Evans School Review Vol 2, Num. 1, Spring 2012, p. 26-46

Trafikanalys olycksstatisk 2012, (http://www.trafa.se/vagtrafikskador). Fetched: 2014-06-09.

Trafikverket (a), (http://www.trafikverket.se/Privat/I-ditt-lan/Vastra-gotaland/Vastsvenska-paketet/Vad-ar-nyttan-med-Vastsvenska-paketet/). Fetched: 2014-04-01.

Trafikverket (b), (http://www.trafikverket.se/Privat/I-ditt-lan/Vastra-gotaland/Vastsvenska-paketet/Sa-finansieras-Vastsvenska-paketet/). Fetched: 2014-03-28.

Trafikverket (c), (http://www.trafikverket.se/PageFiles/25435/pm_vagtrafikens_utslapp_130902_ny.pdf). Fetched: 2014-04-05.

Trafikverket (d), (http://www.trafikverket.se/PageFiles/96362/rapport_forsta_aret_med_vastsvenska_paketet.pdf). Fetched: 2014-05-07.

Transportstyrelsen (a), (http://www.transportstyrelsen.se/Global/Publikationer/Vag/Trangselskatt/Trängselskatt_i_Sverige_ENG.pdf). Fetched: 2014-04-10.

Transportstyrelsen (b), (http://transportstyrelsen.se/sv/Vag/Trangselskatt/Trangselskatt-i-goteborg/Tider-och-belopp-i-Goteborg/). Fetched: 2014-04-15.

Västsvenska paketet, (2011), Sammanställning av målen. Trafikverket.

Västtrafik annual report 2013 (http://www.vasttrafik.se/Documents/Dokumentbibliotek/vasttrafik-arsredovisning-2012.pdf). Fetched: 2014-04-15