

Industrial and Financial Economics
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**EVALUATION OF DEMAND FOR INTERDEPENDENT
INFRASTRUCTURE INVESTMENTS**

- THE CASE OF THE GÖTA ÄLV VALLEY

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ABSTRACT

Our thesis aimed to describe the demand for transportation between Göteborg and Trollhättan in such a way that it could be used for decision making. Furthermore, we aimed to draw parallels between Norge/Vänernbanan and Svealandsbanan. Finally, we wanted to decide if investments should be made in R45, in Norge/Vänernbanan, or in both. A survey among commuters in the area between Göteborg and Trollhättan was performed and company interviews with companies in the municipalities of Göteborg, Ale, Lilla Edet, and Trollhättan were conducted. Furthermore, we explained how scenario analysis can be applied within the field of transportation when determining how an increased capacity affects the demand for transportation and how the demand affects the payoff of infrastructure investments. From our survey and interviews, we can conclude that transfer effects may be realized if investments in R45 and in Norge/Vänernbanan are made. Companies in the area demand infrastructure investments because of recruiting and commuting problems. We suggest expanding R45 into four lanes with a railing in the middle and intersections below or above the road, to increase the bus frequency, and to investigate whether it is possible to increase the train frequency and/or investing in high-speed trains while keeping the current track capacity.

Key Words:

Infrastructure investment, elasticity, cross elasticity, transfer effect, “generalized cost”, consumer surplus, transport modeling, Limdep, Sampers, nettonvärdeskvot, multinomial logit model.

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1 BACKGROUND

1.1 Infrastructure Investments and Users' Benefits

1.1.1 Introduction

Many countries regard infrastructure as being a critical success factor for internationalization and for regional development. These countries also regard missing links or missing networks in the infrastructure as factors that could reduce the productivity in a region significantly¹. Improved networks in the infrastructure may improve the accessibility within a region, since the number of workplaces that can be reached in a certain time increases through an investment. Infrastructure investments usually result in the largest effects in areas where the economic growth is restricted by limited accessibility.

Usually, infrastructure investments involve high investment costs. The positive effects, such as increased accessibility, that may be obtained through an infrastructure investment must be considered in relation to the high investment cost. In Sweden, one uses a measure called the “nettonuvärdeskvot” (NNK) in order to take account of different factors, such as the future development and possible changes of the population, economy, and the business world, that may affect the cost and the social surplus² of an infrastructure investment. The NNK is calculated as benefits minus costs and then this value is divided by the investment cost. The value received is the utility per invested SEK by incorporating an investment within a limited investment budget³.

The NNK is the measure used by Banverket (the Swedish National Rail Administration), Vägverket (the Swedish National Road Administration), and by the government in Sweden when valuing infrastructure investments. The government decides which infrastructure investments that should be undertaken. However, Vägverket is responsible for the planning and administration of road investments and Banverket is responsible for the planning and administration of railway investments. Other investments than the actual building of a road or a railway, such as the investment in high-speed

¹ Polak & Heertje (2000)

² Social surplus is the surplus or benefits enjoyed by society as a whole.

³ Bergendahl (2002)

trains or the investment in an increased bus or train frequency, are usually administered by Statens Järnvägar (SJ) and local public transportation companies, such as Västtrafik.

In principle, one should undertake all infrastructure investments that have a positive NNK, but due to the fact that infrastructure investments normally are very expensive, the government is not able to undertake all these investments. Therefore, the NNK is used to enable the government to rank and to prioritize different infrastructure investments. Accordingly, the NNK can be applied to all infrastructure investments in Sweden and thereby one quite easily is able to compare these investments with each other. However, one weakness with the current way of comparing and deciding between different investments is the fact that it is very difficult to prioritize between integrated investments, which are interdependent, and independent investments⁴.

This thesis will evaluate the demand for road 45 (R45) and for Norge/Vänernbanan between Göteborg and Trollhättan, which is one example of integrated infrastructure investments. Currently, R45 and Norge/Vänernbanan mainly act as a transport corridor between these two cities and constitute an important link between Göteborg and Trollhättan. Since R45 and Norge/Vänernbanan run parallel, between Göteborg and Trollhättan, an investment in either the road or the railway would probably affect the demand for both the road and the railway. That is, the demand for the road and for the railway would probably change, which could result in transfer effects between different modes of transportation. The importance of transfer effects is one reason why one should evaluate interdependent investments and independent projects differently.

The current national model used by Vägverket, Banverket, and SIKA (Statens Institut för Kommunikationsanalys) when estimating the demand for infrastructure investments is a model called Sampers. The results obtained from Sampers are included in the NNK in order to capture demand effects. It has been discovered that Sampers produces transfer effects, i.e. cross elasticities,

⁴ Bergendahl (2002)

that seem to be too low⁵. This means that one has difficulties in accurately estimating the demand for two interdependent infrastructure investments. If one is not able to estimate the demand in an accurate way, the true effects and payoff of an infrastructure investment for different regions can be misjudged. In the worst case, a misjudgement could lead to an investment that does not pay off since the true demand for the investment is too low.

1.1.2 Infrastructure Investments and Region Enlargement

If the estimation of the demand for transportation reflects the true demand, the probability of choosing an investment solution that will contribute to economic growth and region enlargement increases. A region can be a whole country or just a specific part of a country. A region can also be characterized by the extent that a specific market, such as the working force, can be extended to other areas. In a functional region, the working force is integrated and the possibility of quick personal contact is large, which enables different industries and companies to more easily cooperate. The size and enlargement of a region depend on the number of companies, the total number of employees, and the number of customers in the region. An enlargement can be made possible in several different ways, such as new company establishments or an improved infrastructure. In a region where the infrastructure is relatively efficient, an infrastructure improvement probably will have less effect than in another region where the current infrastructure is less efficient. Additionally, improved infrastructure and transport opportunities usually have a larger effect on regions with large populations, large market potential, and where the capacity of the infrastructure is used to a larger extent than in other regions⁶. However, in weak regions other factors than infrastructure improvements may be more important and have a larger effect on the society. In these weak regions it may, for example, be more beneficial to the area to increase the level of education among the inhabitants. An infrastructure improvement in a weak region can have a negative effect since the existing local business industry may be driven out of competition by companies situated outside the local industry, which now have access to the local industry through the infrastructure improvement⁷.

⁵ Helena Braun (071103)

⁶ Johansson & Klaesson (2003)

⁷ Fröidh (2003)

The frequency of commuting trips between different municipalities is usually related to the quality of the infrastructure in a specific area. An infrastructure improvement that facilitates the commuting within the region can make people start considering working for companies that seemed unreasonably distant before the infrastructure improvement was made. For example, if investments were undertaken in R45 and in Norge/Vänernbanan, people living in Göteborg would probably find it more attractive to commute to Trollhättan than they currently do. An infrastructure improvement could also enable companies to reach a larger number of customers. It has been analyzed to which extent people tend to want to travel when the traveling time changes. The traveling time affects the demand for transportation in a non-linear way. The analysis showed that people whose traveling time is between 15-45 minutes are more strongly affected by traveling time changes than people whose traveling time lies outside this interval⁸.

In Sweden, SCB (Statistiska Centralbyrån) and NUTEK (Verket för Näringslivsutveckling) continuously divide the Swedish municipalities into “lokala arbetsmarknadsregioner (LA-regioner)”, which can be translated as local working force regions (LA-regions). A LA-region can be defined as a coherent area that consists of one or several municipalities based on the amount of commuting over the borders in relation to the total number of employed persons within the municipalities⁹. Over time, the number of LA-regions in Sweden has decreased and their sizes have increased, which proves that the Swedish working force has become more and more integrated. This process is called region enlargement.

A larger region increases the probability for good matching between employers and households in the working force market. The households are faced with more jobs to choose from and the employers can choose their employees from a larger number of people and thereby the probability of finding the right employees increases. Furthermore, companies in a larger region can more

⁸ Johansson & Klaesson (2003)

⁹ Fröidh (2003)

easily use and enjoy economies of scale, which increases the overall productivity and contributes to economic growth¹⁰.

The sizes of the existing LA-regions in Sweden vary significantly. In other words, the basic conditions and growth opportunities in the different LA-regions are completely different. The figure below presents a comparison among the sizes of the existing 100 LA-regions in Sweden:

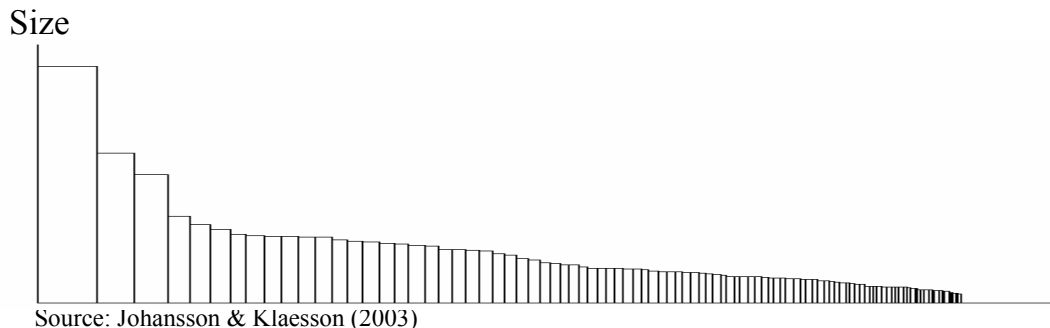


Figure 1.1

According to Börje Johansson and Johan Klaesson, one can decrease the differences between different regions in the southern part of Sweden through good infrastructure and new transport opportunities¹¹. In the northern part of Sweden, however, infrastructure and the transport sector cannot contribute to region enlargement in the same way as in the southern part of the country because in the northern part the regions are very small and the distances between them are very large.

1.2 Demand for Transports

Demand for transportation can be expected to increase with economic development. The demand for transport services tends to be complementary to the demand for other goods and services. Therefore, demand for transportation is normally regarded as a derived demand. A derived demand for transportation means that the transportation is not needed for its own sake; instead the transportation is demanded in order to satisfy other needs. However, demand for transportation such as pleasure trips and cruises could not be regarded as a derived demand. It is difficult to determine the distribution between the

¹⁰ Johansson & Klaesson (2003)

¹¹ IBID

proportion of transportation that results from a derived demand and the proportion that takes place for its own sake. The existing investment strategies for infrastructure further explain the complexity of demand for transportation. When investing in infrastructure one could either expand through a passive strategy or by an active strategy. An active strategy means that the society uses the infrastructure as a generator for regional and national development. This strategy involves a certain degree of risk taking since it assumes a response from the private sector in the form of increased investments to succeed¹². A passive strategy means that the society invests in infrastructure when the economy and the demand have grown so much that the existing infrastructure shows a distinct capacity shortage.

Two typical characteristics of the demand for transportation are its variation over time and the possibility to make substitutions. The demand for transportation fluctuates regularly over time. For example, in urban areas the demand for transports seems to be strongly connected to the regular working hours at different companies. That is, the demand for transports tends to be higher in the early morning and in the late afternoon. Another example of how the demand for transports fluctuates over time is the fluctuation during different seasons. As mentioned above, the demand for transports fluctuates regularly over time but one can also observe seasonal peaks. During the summer, the demand for rail and air services tends to increase since the summer is a typical holiday season¹³. When going on holiday, people choose between different kinds of transports and choose the type of transport that fits their specific purpose. Consequently, when going on holiday people always have the choice of substitution between different kinds of transports. The possibility of substitution between different kinds of transports is also a characteristic of the demand for transportation among people who commute to work over the year. For example, an employee that usually goes by train to work might start using the bus instead if the bus services change so that the bus seems more desirable for this specific employee than the train that the employee normally uses. However, substitution between different transportation modes involves costs of different kinds, both for the individual commuter, the company providing

¹² Fröidh (2003)

¹³ Button (1993)

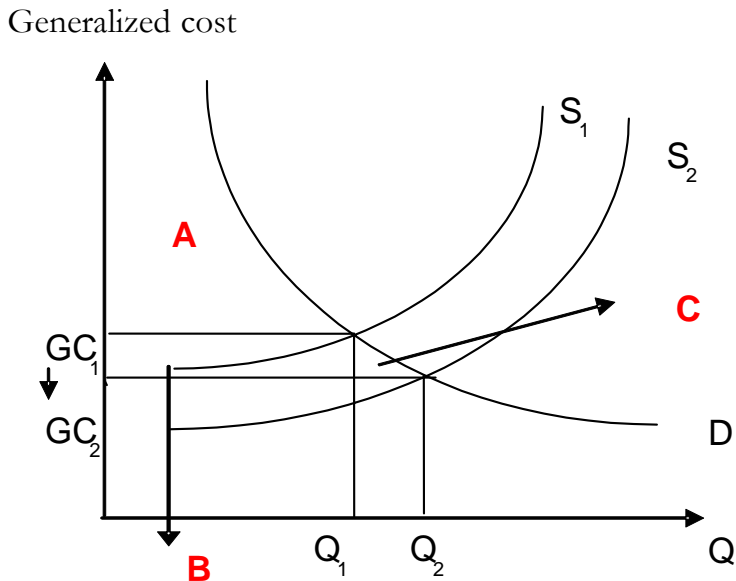
public transportation, and for the owners of the infrastructure. For example, if a train commuter was to substitute the train alternative with the car alternative, the commuter may need to buy a car first. Another example may be the increased cost facing a bus company when it needs to buy more buses because of an increased demand for the bus alternative. Both the variation over time in the demand for transportation and the opportunity to substitute one mode for another are factors that affect the balance between the supply and the demand in the transportation sector.

1.2.1 Relationship between “Generalized Cost” and Consumer Surplus

Transportation and travel take place on a market that is significantly different from the ideal market model where a well-defined good has a price defined according to an equilibrium between supply and demand. Equilibrium in the ideal market model exists when all individuals have made the best possible choices in the light of their preferences and information and when all these choices have been coordinated and made compatible with each other. The equilibrium price is the price where the quantity demanded equals the quantity supplied. When dealing with supply and demand in the transport sector, the equilibrium condition is more complicated since one has to consider the fact that in addition to costing money, traveling also “costs” time. Therefore, the transport market usually deals with a “generalized cost” where the “cost” of time is included. In its simplest form, a “generalized cost” is a linear combination of time and cost, where time is converted to money by evaluating the value of traveling time savings. However, in larger contexts the “generalized cost” can include other variables as well that may affect the traveling decisions by individuals. Thereby, the “generalized cost” can be seen as a reflection of indirect utility. The supply relationships in the field of transportation often are focused on the non-monetary variables since these variables seem to affect the demand for transportation in a major way. The demand for transportation more often is concerned with the performance of the transport system than with the monetary costs involved. For example, the demand for a specific road can be affected by a high degree of congestion or perhaps a large number of accidents. Accordingly, in the field of transportation both the demand and the supply are related to the “generalized cost”¹⁴. The

¹⁴ Hensher & Button (2000)

graph below shows the relationship between the supply and the demand in the transportation sector if the supply changes through an infrastructure investment:



Source: www.internationalecon.com (271103)
Graph 1.1

The graph shows how an improved infrastructure would affect the “generalized cost”. An improved infrastructure increases the capacity of the road or railway in question and hence the supply curve shifts to the right (from S_1 to S_2). This type of shift in the supply curve results in a reduced “generalized cost”, that is, the cost is reduced from GC_1 to GC_2 . The reduction in the “generalized cost” may depend on a reduced traveling time, which has become possible through an improved infrastructure. Through an increased supply, the travelers’ consumer surplus increases. Consumer surplus can be defined as the difference between what the travelers are willing to pay for transportation and the price that the travelers actually have to pay to use the road or railway. The consumer surplus is represented by the area A in the graph above before the infrastructure investment is undertaken. If an infrastructure investment is undertaken, the consumer surplus increases. The new consumer surplus can be found in the graph as area A + area B + area C. However, the total consumer surplus is divided between different travelers. The travelers who were willing to pay GC_1 for transportation now have a consumer surplus that equals area A + area B.

The remaining part of the consumer surplus, that is area C, belongs to those travelers who were not willing to travel at the price of GC_1 but only at the new price of GC_2 ¹⁵.

1.3 R45 and Norge/Vänernbanan

1.3.1 The Göta Älv Valley

R45 and Norge/Vänernbanan run parallel to the Göta Älv. Between Göteborg and Trollhättan the road and railway go through two other municipalities, which are Ale and Lilla Edet municipalities. Göteborg is the largest municipality of these four and has a population of about 500,000, Trollhättan is the second largest with about 50,000 inhabitants and Ale is the third largest with approximately 25,000 people living in the area. The municipality of Lilla Edet is the smallest and has a population of 13,000. From 1950 until today one can see a slow increase in population in the municipalities of Göteborg, Trollhättan and Ale. Lilla Edet municipality, on the other hand, experienced a slow decrease in its population during the years 1950-1960 and then a slow increase in its population until year 2000 when the population started to decrease again. Over a period of five years (1996-2000), one can conclude that, on average, the municipalities of Ale and Lilla Edet have had negative patterns of migration whereas Göteborg and Trollhättan have had positive patterns of migration. Currently, 656 companies are registered in Ale, 13,717 in Göteborg, 323 in Lilla Edet and 1,033 in Trollhättan.¹⁶ Table 1.1 presents the five largest companies, in terms of the number of employees, in each municipality.

¹⁵ www.internationalecon.com (271103)

¹⁶ www.foretagsfakta.se (030901)

Ale Municipality	Göteborg Municipality	Lilla Edet Municipality	Trollhättan Municipality
Eka Chemicals AB, Bohus 800 employees	AB Volvo 25,400 employees	SCA Hygiene Products, Edet Bruk, Lilla Edet 500 employees	SAAB Automobile 7,600 employees
Kraftelektronik AB, Surte 100 employees	Volvo Car Corporation 27,380 employees	Solhaga By AB, Lödöse 170 employees	Volvo Aero Corporation 4,500 employees
Tekniska Förvaltningen, Alafors 90 employees	Trelleborg Automotive AB 9,600 employees	Electrolux Filter AB, Nygård 120 employees	EDS 1,200 employees
Göteborgs Spårvägar AB, Älvängen 60 employees	Sodhexo AB 8,500 employees	Knauf Danqlips GmbH Inlands kartongbruk 100 employees	Lear Corporation AB 800 employees
SGS-Scandinavian Garment Service, Älvängen 50 employees	Gunnebo AB 8,200 employees	Lilla Edets Industri & Fastighets AB, Lilla Edet 46 employees	Högskolan i Trollhättan/Uddevalla 470 employees

Source: www.foretagsfakta.se (201103)

Table 1.1

1.3.2 Characteristics of R45 and of Norge/Vänernbanan

Road 45 (R45) stretches from the southern part of Italy to Nordkap, which is located in the northern part of Norway. The section of R45 that goes through Sweden is a part of the Swedish national road system. R45 is an important regional as well as an important national road. The traffic on R45 is often dense and is sometimes also flooded because of its location close to the Göta Älv. From Göteborg north to Nödinge, the road has two lanes in each direction, but further north there is only one lane in each direction. The road accessibility is considered as rather bad and therefore the Swedish government has decided that R45 should be reconstructed and improved. The major reasons for reconstruction and improvement of the road are to increase its capacity and to reduce the number of accidents on the road¹⁷. In comparison with many other roads in Sweden, there are significantly more accidents on R45. For example, during 1994-1998 there were on average 80 accidents per year on E6 between Uddevalla and the Norwegian border, whereas the average number of accidents on R45 between Göteborg and Trollhättan amounted to 191. It is worth noticing in this comparison that there are about 111 kilometers between Uddevalla and the Norwegian border but only 80 kilometers between Göteborg and Trollhättan¹⁸.

¹⁷ Banverket, Ale kommun & Vägverket (2002)

¹⁸ Västsvenska Industri- och Handelskammaren (1999)

North of Göteborg, R45 runs parallel to a railway line called Norge/Vänernbanan. This line starts in Göteborg and ends in Erikstad. In Erikstad, Norgebanan turns west and ends in Kornsjö in Norway, whereas Vänernbanan continues further north in Sweden and ends in Karlstad. Norge/Vänernbanan is one of the most frequently used single-track railways in Sweden and is used for both national and international transports of people and goods. Currently, the railway does not have any stops between Göteborg and Trollhättan.



Source: Västsvenska Industri- och Handelskammaren Rapport nr 2003:5

Figure 1.2

In the current plan for R45 and Norge/Vänernbanan, the government aims to invest in both the road and the railway. The government's plan involves an expansion of R45 into a four-lane road with a railing in the middle and intersections below or above R45. Regarding Norge/Vänernbanan, the government is planning to expand it into double tracks and to offer high-speed

train services. Furthermore, the plan involves investments in six train stations in Ale municipality¹⁹. The government aims to realize the investments in Norge/Vänernbanan in year 2008 at the earliest and in 2011 at the latest. The improvements to R45 have been postponed and will be realized sometime after year 2012.

Similar Infrastructure Investments in Sweden

To undertake infrastructure investments where an important road and railway run parallel to each other is rather unusual in Sweden²⁰. The planned investments in R45 and in Norge/Vänernbanan are one such case. According to Fröidh, there are mainly three other such cases in Sweden that are comparable to R45 and Norge/Vänernbanan²¹. These cases are Väst kustbanan and E6, Botniabanan and E4, and Svealandsbanan and E20. Väst kustbanan runs between Malmö and Göteborg, but to study a similar distance that is comparable to the distance between Göteborg and Trollhättan, one could look at the section of Väst kustbanan that goes between Lund and Helsingborg. This section has been divided into three different subsections, which are Lund-Kävlinge, Kävlinge-Landskrona, and Landskrona-Helsingborg. The investment plan is to build double tracks in all of these three subsections and also to invest in five train stations in total. Currently, double tracks exist between Kävlinge and Helsingborg whereas the investment in double tracks between Lund and Kävlinge will be completed in 2005. The goal with the investments between Lund and Helsingborg is to facilitate the commuting²². Botniabanan will be a single-track railway that will go between Nyland, in the municipality of Kramfors, and Umeå. The building of Botniabanan started in 1999 and is planned to be completed in 2008. Svealandsbanan was opened for traffic in 1997 and goes between Eskilstuna and Södertälje. In Södertälje, one can easily take the Grödinge Line to Stockholm. Svealandsbanan is partly a double-track railway and it includes five train stations between Eskilstuna and Stockholm.

¹⁹ www.vv.se (191103)

²⁰ Oskar Fröidh (091203)

²¹ IBID

²² www.banverket.se (101203)

2 PROBLEM DISCUSSION

Sampers, the current national demand forecasting model for passenger transportation, was developed in 1999 by SIKÅ. The results obtained in Sampers are included in the NNK. The Sampers forecasting model can be used as a basis when measuring factors such as demand effects of new infrastructure and new transports supply, demand effects of changing factors, and regional effects²³.

SAMPERS

- Commissioned by SIKÅ in 1999
- Forecasts the demand for passenger transportation
- Four-stage model, which also can be called an assignment model
- Four steps to calculate the demand: Trip generation, trip distribution, modal split, and route choice
- Can among other factors measure demand effects of new infrastructure, accessibility effects, regional effects, and demand effects of changing socio-economic factors
- One national model, five regional models, and one international model

The Sampers forecasting model has a number of weaknesses, which may affect the results and consequently the NNK in an undesirable way. A recent discovered weakness with Sampers is that it does not consider transfer effects between different modes of transportation in an appropriate way²⁴. This weakness plays a major role when evaluating two interdependent infrastructure investments simultaneously, which is the case with R45 and Norge/Vänernbanan. One must analyze which factors, such as traveling time, comfort, and mode frequency, affect different types of commuters and to what extent these groups are affected by changes in these factors. If one cannot measure and describe the demand for transportation appropriately and determine possible transfer effects between different modes, it is very difficult to determine the true effect that the demand for transportation has on the payoff from an infrastructure investment.

²³ Fröidh (2003)

²⁴ Helena Braun (071103)

A new infrastructure investment can be viewed differently by individuals, companies, and by society. Individuals' demands for a new road or a new railway depend on whether the investment means new or improved ways for them to get to their current work, opportunities to reach new job areas, or perhaps the attraction to new and different vacation areas. Companies can experience opportunities to expand their business, which could involve more products or new employees, through a new infrastructure investment. Furthermore, infrastructure investments can also lead to economic growth and social surplus. Usually, the regional development in the areas around the investment will be difficult to see in the first few years after the investment has been made. The fact is that the regional development depends on the demand for transportation among the individuals and the companies in the area where an infrastructure investment has been made. The discussion above results in the following research questions:

- a) How can one estimate and describe the evolution of demand for transportation in such a way that it could be used for decision-making?
- b) How does the demand for transportation affect the payoff of the infrastructure investment?
- c) Which effect will an increased capacity have on the demand and how can one evaluate an expanded traffic?

The research questions stated above are especially interesting when considering the weaknesses in Sampers. Sampers is not able to accurately capture transfer effects between different modes of transportation since the model estimates the demand for road transportation and for rail transportation separately. Therefore, it is important to determine if there are alternative ways of measuring these transfer effects. Transfer effects are also interesting to study since R45 and Norge/Vänernbanan are interdependent investment projects. Accordingly, an increased capacity in either the road or the railway may affect the demand for both the road and the railway.

When planning the development for R45 and Norge/Vänernbanan one can consider different alternatives depending on the demand for transportation in the area. One could improve both R45 and Norge/Vänernbanan, one could only

invest in the road, or one could only focus on an investment in an improved railway. Currently, the government is planning to invest in both the road and the railway. R45 will be expanded into a four-lane road with a railing in the middle and intersections below or above the road. The current investment plan for Norge/Vänernbanan is to expand it into double tracks, to build six train stations in Ale municipality, and to provide high-speed train services²⁵. Whether an investment in the road, in the railway, or in both, is the most suitable depends on many different factors, but the demand for road traffic, the demand for railway traffic, and possible transfer effects should play an important role when making the final decision. Therefore, an additional aim is to study the following research problem from a demand-oriented perspective:

- d) Should an investment in the road, in the railway, or in both, be undertaken?

Many train stations between Göteborg and Trollhättan would result in a slower train ride than if only a few stations would be constructed. When trying to find the optimal investment alternative for Norge/Vänernbanan it is interesting to make comparisons to similar investments. As discussed in section 1.3.2, railways that could be compared to Norge/Vänernbanan are Väst kustbanan, Botniabanen, and Svealandsbanan. However, we found it most appropriate to make a comparison with Svealandsbanan. There are mainly three reasons why we argue that Svealandsbanan is the most appropriate. Firstly, the construction of Svealandsbanan is, in comparison to Väst kustbanan and Botniabanen, completely finished. Secondly, even if information is available for all three railways, the information about Svealandsbanan is more valuable than the information about the other two railways. This mainly depends on the fact that Oskar Fröidh at the Royal Institute of Technology (KTH), Stockholm, has written a doctoral thesis about Svealandsbanan and the effects on demand through the introduction of high-speed train services. Thirdly, the length of Svealandsbanan is advantageous in the sense that it is more similar in length to Norge/Vänernbanan between Göteborg and Trollhättan than the two other railways are.

²⁵ www.vv.se (191103)

The area between Göteborg and Trollhättan is characterized by small villages and smaller companies²⁶. The majority of the individuals and companies that will be affected by an improvement of R45 and Norge/Vänernbanan live in or are situated in either Göteborg or Trollhättan. The concentration of people and large companies in Göteborg and Trollhättan further strengthens the argument from above that a very interesting comparison is the one with Svealandsbanan in the Stockholm area where Stockholm and Eskilstuna attract the most people and companies. The possible comparison to Svealandsbanan resulted in the following research questions:

- e) What parallels can be found between the possible investment in Norge/Vänernbanan and the investment in Svealandsbanan?
- f) What can one learn from these parallels and how can this knowledge be used when making the final investment decision regarding Norge/Vänernbanan?

²⁶ Only four companies in Ale municipality and four companies in Lilla Edet municipality have more than 50 employees.

2.1 Purpose

In our thesis, we will focus on demand effects through different infrastructure investments between Göteborg and Trollhättan and thereby answer the six research questions stated in the problem discussion.

The first purpose is to estimate and describe the evolution of the demand for transportation between Göteborg and Trollhättan in such a way that it could be used for decision-making. Furthermore, we want to analyze how the demand for transportation affects the payoff of the infrastructure investment, what effect an increased capacity has on the demand, and how one can evaluate an expanded traffic. These aims could be fulfilled through investigating demand elasticities and cross elasticities among different types of commuters and by evaluating the demand for transportation among companies in the area. Furthermore, a scenario analysis can be used in order to deal with uncertain factors, such as how the demand affects the payoff of an investment and the effects on demand of an increased capacity.

The second purpose is to, from a perspective of interdependencies in demand for road and rail transportation, find arguments for whether one should invest in the road, in the railway, or in both.

The third purpose is to draw parallels between the possible investment in Norge/Vänernbanan and the investment in Svealandsbanan. Furthermore, we want to investigate what one can learn from this comparison and how this knowledge can be used when making the final investment decision for Norge/Vänernbanan.

3 METHODOLOGY

3.1 Working Process

In our thesis, the aim of collecting secondary data was to get a general picture of the factors that are considered when deciding which infrastructure investments to make. More specifically, we wanted to learn about how the demand for infrastructure investments is calculated in Sweden when using Sampers and to find out if Sampers has any weaknesses. The impact of infrastructure investments and its effects on social surplus were also of great interest to us and we wanted to learn more about how these effects can be approximated. Our secondary data was collected through a literature review, but also through a wide range of reports and statistics from Banverket, Vägverket, SJ, SIKKA, Green Cargo, Västtrafik, Statistiska Centralbyrån and Västsvenska industri-och handelskammaren.

The knowledge gained from our literature review enabled us first of all to define our research questions. In order to answer our research questions, we needed to complement our collection of secondary data as well as collect primary data. When collecting primary data, we performed a survey and conducted interviews. The survey had mainly three aims. Firstly, we wanted to map commuters' preferences for modes of transportation if the traveling time between home and work varied. Secondly, we were interested in how the mode frequency affected their choice of a certain mode of transportation. Finally, we wanted to find out the importance of different factors, such as comfort and waiting time, for commuters when traveling by train and bus. Through our interviews, we aimed to find out how a selection of large companies in Göteborg municipality, Ale municipality, Lilla Edet municipality, and in Trollhättan municipality use R45 and Norge/Vänernbanan and to find out their views on investments in R45 and Norge/Vänernbanan.

When analyzing the results from our survey, we used a quantitative approach by utilizing a multinomial logit model, which is connected to random utility theory. The interviews, on the other hand, were analyzed by using a qualitative approach to evaluate the information given by the companies. Furthermore, we

also used a comparative approach when comparing our study of R45 and of Norge/Vänernbanan to Oskar Fröidh's study of E20 and of Svealandsbanan. All three approaches that we used will be further explained in the following sections.

To structure our analysis, we decided to divide it into three different parts. In the first part, we aimed to answer how one may describe the evolution of demand along R45 and Norge/Vänernbanan in such a way that it could be used for decision-making. In the second part, we made comparisons between Norge/Vänernbanan and Svealandsbanan, and in the third part we evaluated which infrastructure investments that should be taken in R45 and Norge/Vänernbanan from a demand-oriented perspective. Since the second and the third part are closely related, we decided to include these two parts in the same chapter. The resulting analysis structure is presented below:

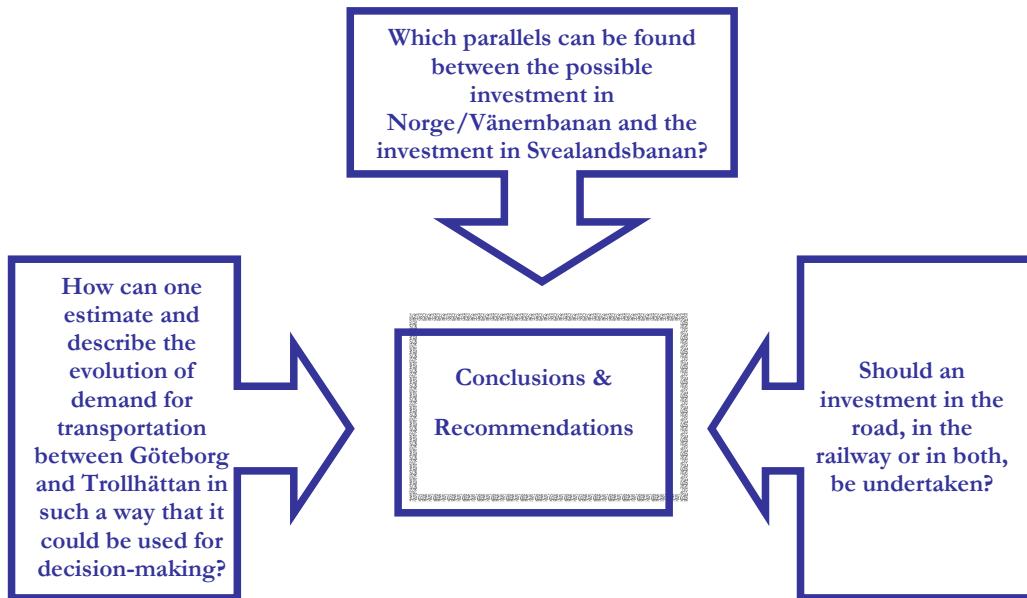


Figure 3.1

3.2 Quantitative Approach

3.2.1 Travel Demand Models

In travel demand models, there are mainly three different approaches that can be used. These approaches are the traditional four-stage transport approach, the microeconomic approach of travel choice, and the activity-based approach. At an early stage we discovered that the activity-based approach was not

appropriate to use for our study since this approach lacks a clear methodological orientation.

The Traditional Four-Stage Transport Approach

The four-stage transport approach is an aggregated approach. This approach focuses on zones as generators of travel and as destinations for travel. The four-stage transport approach is suitable to use when planning for large scale and long range transport planning. Sampers, which is the current demand forecasting model used by SIKa, Vägverket, and Banverket, is based on the traditional four-stage model. This approach is appropriate to use in Sampers since one wants to generalize its findings to different regions.

The four-stage travel demand process relies on the passenger demand model presented below, which forecasts the predicted traffic flows ($T(k,i,j,m,r)$):

$$T(k,i,j,m,r) = G_i^k T_{if}^k M_{ij}^{km} R_{if}^{kmr}$$

Formula 3.1

G_i^k is the total number of trips made by people with characteristics k generated in zone i , T_{if}^k represents the proportion attracted to zone j , M_{ij}^{km} represents the proportion of T_{if}^k related to mode m (for example, train or bus) and R_{if}^{kmr} represents the route choice made by people with characteristics k . These four factors, $G_i^k T_{if}^k M_{ij}^{km} R_{if}^{kmr}$, represent the different stages in the four-stage model. The four stages are trip generation, trip distribution, modal split, and route choice. The aim of these stages is to predict the traffic flows on links of a transport network by using the knowledge about land use, car ownership, the economy, population and travel conditions. The demand forecasting process when using the four-stage model, which also can be called an assignment model, is presented below:



Source: Polak & Heertje (2000)
Figure 3.2

Trip generation is the first stage in the four-stage model and it aims to determine the number of trips of a certain kind leaving a specific zone during a specific period of time. There are mainly two types of methodologies that could be applied when determining the trip generation, which are linear regression and category analysis.

Through the second stage, which is trip distribution, the origin and the destination of the trip are linked.

The purpose of modal split is to predict the number of trips by a certain mode of transportation made by people with certain characteristics who are traveling between a certain starting point and destination. Mode selection is often regarded as a choice between private transportation and public transportation. Some groups of travelers are practically eliminated before they choose a mode of transportation. For example, travelers who do not have a driving license or who are not able to afford a car must usually use the public transportation system. Therefore, one can say that the first step in the modal split is to determine the proportion of the population in each zone that is more or less forced to use the public transportation. The modal split is able to provide useful information for transportation policy in general, but also to provide information for specific infrastructure investment decisions such as whether to invest in a road or not.

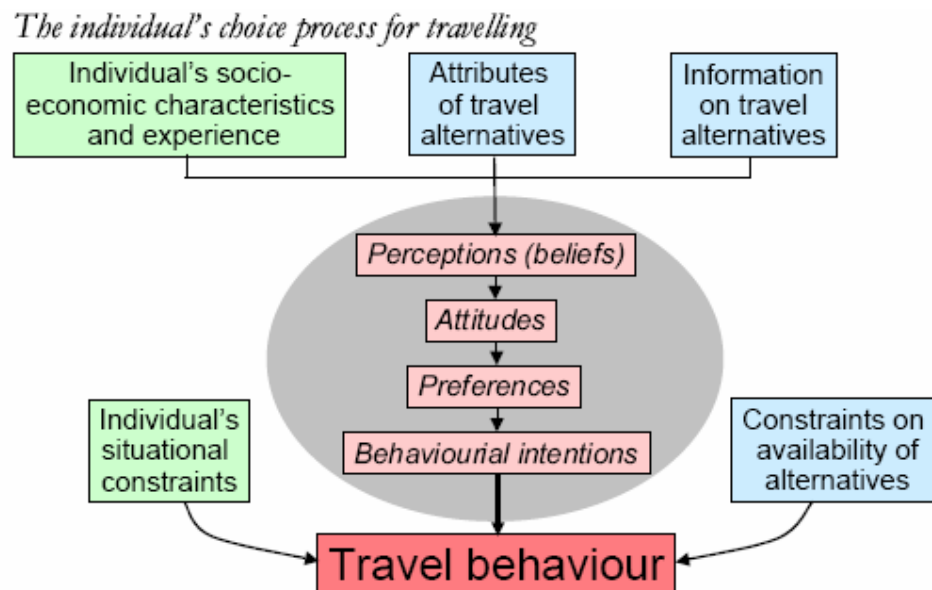
The last stage in the aggregate four-stage model is the route choice. When performing this stage, one has to assume that all trips between different zones follow the optimal route, where optimal refers to the minimization of “generalized cost”. By making the assumption of optimal routes, one also assumes that travelers are sufficiently familiar with the transportation network and hence are able to make an optimal route choice. This assumption is considered as reasonable for work and shopping trips, but doubtful for pleasure trips.

The aggregate four-stage approach has several methodological and technical problems. For example, there is no feed back between the different stages in the four-stage model, which results in that errors in one of the four stages will

affect other stages, and hence the final outcome of the four-stage model. As previously mentioned, the four-stage model is an aggregate model, which is most appropriate for large-scale and long-term transport planning. The aggregate four-stage model is not particularly well suited for finer scaled, shorter time frame and low capital cost planning, which more often tends to be used within transportation planning today. Accordingly, one can question how up to date this model really is²⁷.

The Microeconomic Approach of Travel Choice

The microeconomic approach, which also can be called the disaggregate approach, focuses on individuals or households rather than zones, the focus in the aggregate four-stage model. Furthermore, in contrast to the four-stage model, the microeconomic approach assumes that individuals only have limited knowledge in route choice decisions. That is, in the microeconomic approach one assumes that a traveler’s level of knowledge concerning different routes is dependent on his or her individual experiences and the way of obtaining the information about different routes. Recently, several researchers have confirmed the literature stating that individuals are faced with limited information when making their choice of transportation mode and route²⁸. The figure below presents the individual decision making process:



Source: Fröidh (2003)

Figure 3.3

²⁷ Polak & Heertje (2000)

²⁸ IBID

The microeconomic approach is based on random utility choice theory, which is based on the concept of utility (preference) maximization. The most widely used functional form of the random utility choice model is the multinomial logit model, which is considered as being rather easy to use and interpret. In utility maximization, one assumes that in each case the decision-makers choose the alternative where their individual utility is the highest. That is, one assumes that decision-makers make rational decisions²⁹. The decision maker's utility in different alternatives is not known by researchers. Therefore, one divides the utility function into one deterministic component and one random component. The deterministic component is a function of the attributes of the alternative and individual characteristics, such as socio-economic factors. The random component of the decision maker's utility function includes unknown and/or unobservable factors, such as individual preferences. The utility maximization function is expressed in the following formula:

$$U_{i,q} = V_{i,q} + \varepsilon_{i,q}$$

Formula 3.2

U represents the utility for an alternative i to an individual q . V stands for the deterministic component and ε for the random component with respect to alternative i for individual q ³⁰.

There are several explanations to why one chooses to focus on individuals and households, as in the microeconomic approach instead of focusing on zones, which is the case in the four-stage model. One explanation is concerned with the fact that one wants to find a theory that is able to explain how and why different patterns in traffic flow occur. Another explanation is more technical and is concerned with statistical efficiency. One believes that the potential of receiving more accurate statistical results is greater in the disaggregate model than in the aggregate model, since one does not generalize the findings in the disaggregate model³¹.

²⁹ Long (1997)

³⁰ IBID

³¹ Polak & Heertje (2000)

Choice between the Four-stage Transport Approach and the Microeconomic Approach of Travel Choice

We chose to use the microeconomic approach of travel choice. One reason why we chose this approach is because we find it reasonable to assume that individuals' preferences for future possible investments are based on utility maximization. Additionally, since we are only interested in individuals' preferences and behavior along R45 and Norge/Vänernbanan, we found it appropriate to use a random utility model since this model has been proven to treat individual decision making in an exemplary way³².

3.2.2 Usage of Multinomial Logit Model in Survey Analysis

To analyze the results from our survey, we have used the multinomial logit model, which is a functional form of the random utility choice model.

Multinomial Logit Model

The multinomial logit model is a closed-form discrete choice model, which is considered as a straight-forward model to use and interpret. The user-friendliness of the multinomial logit model makes it popular to use in the context of transportation modeling. The multinomial logit model assumes that the random component in the utility function, which was discussed above, is independently and identically distributed across all cases. This kind of distribution is called a Gumbel distribution. When making the assumption that the error terms are independently and identically distributed, one can use the multinomial logit model to calculate the probability for making a specific choice, which in our case is the probability for choosing a specific transportation mode:

$$P_{i,q} = \frac{e^{V_{i,q}}}{\sum_{i'=1}^J e^{V_{i',q}}}$$

Formula 3.3

³² Polak & Heertje (2000)

P represents the probability for individual q to choose alternative i , e stands for the exponential function, V is the deterministic component of the utility of alternative i for individual q , and J represents the number of alternatives³³.

To calculate these types of probabilities, we used a software program called Limdep, which is based on the multinomial logit model. To use Limdep, we had to encode the data collected through our survey. The encoding procedure is presented in Appendix I.

3.2.3 Survey Sample

When collecting data, it is important to distinguish between a census and a survey. A census involves measurement or enumeration of every member of a subject population, whereas a survey involves a sample from the universe. A sample may be small or large, depending on many factors. However, the intention is always to draw a sample from the population that can be considered to be representative of the entire population, no matter how small or large the sample is³⁴.

When conducting our survey, car, bus, and train commuters along R45 and Norge/Vänernbanan were of interest to us. That is, the commuters were required to use R45 or Norge/Vänernbanan in their daily commuting to their work. Furthermore, since we are studying the distance between Göteborg and Trollhättan, the commuters' traveling to some extent had to occur in this area. This method of sampling is called choice based sampling and is not based on a strictly random process. It is used when one is interested in a sample of individuals who already have made a specific decision relevant to the survey. The sample cannot be expanded directly to the total population, but only to the subpopulation of choosers. In this sense it is a biased sample of the total population. However, a sample that is drawn by a standard random process within the chooser group is unbiased for the subpopulation of choosers³⁵.

³³ Hensher & Button (2000)

³⁴ IBID

³⁵ IBID

3.2.4 Choice of Survey Method

Participatory versus Non-participatory Surveys

Surveys can generally be classified into two basic types, which are participatory and non-participatory surveys. In participatory surveys it is necessary for the subjects of the measurements to participate in the survey by answering questions or otherwise taking an active role in the provision of the data to the survey. In non-participatory surveys, measurement is usually done without notifying the people included in the survey. When surveying travelers, non-participatory surveys usually include counting and classifying types of travelers. One may, for example, count the number of train commuters on a certain distance. Since we are concerned with the commuters' preferences for different transportation modes in certain given situations, we found it appropriate to perform a participatory survey, where the commuters were asked a selection of questions³⁶.

Household versus Non-household based Surveys

When performing surveys within the field of transportation one can proceed in several different ways depending on the aim of the survey. Household travel surveys are the primary survey used for transport modeling. This is a demand participatory survey that focuses on households and usually involves surveying some or all of the members of selected households. The household travel surveys can be conducted in several ways. Face to face interviews, telephone interviews, postal surveys, and different combinations of these three methods are some examples. Although this survey method is the primary way of surveying in transport modeling, we found it inappropriate to use this method. The major reason for this statement is that we were not able to find out which individuals in the municipalities of Göteborg, Trollhättan, Lilla Edet and Ale who regularly commute along R45 and Norge/Vänernbanan. Furthermore, it is often very expensive and time consuming to perform household-based surveys³⁷.

Since it was not appropriate to perform a household-based survey, we evaluated the appropriateness of using different non-household based surveys

³⁶ Hensher & Button (2000)

³⁷ IBID

that could be of interest to us. Sometimes, the only satisfactory way to find a sufficient sample of people using a specific means of transport is to survey them while they are traveling, that is, on board the vehicle. Such surveys are mainly participatory, although there are some non participatory surveys that may be conducted on board. Participatory on board surveys generally involve having surveyors on board the vehicle who either interview passengers as they ride or hand out survey forms to be filled out on the vehicle or later. We decided to use the on board survey method by handing out questionnaires on buses and trains on the routes Göteborg – Trollhättan and Trollhättan – Göteborg.

In order to survey car commuters, we performed both workplace interviews and road-side interviews. Workplace surveys are done relatively infrequently, but offer considerable opportunities for collecting useful data. The survey involves selecting workplaces within an urban area and conducting the survey among all employees or a sample of employees at a given workplace site³⁸. To perform workplace interviews we contacted different workplaces in Göteborg municipality, in Ale municipality, and in Trollhättan municipality. It was rather difficult to perform workplace interviews since many companies were not able to provide us with the information we needed due to legal restrictions. However, at some workplaces the representatives who we contacted knew other employees who daily commute on R45 and offered to distribute our survey to these employees. In most cases, these employees were willing to fill out our questionnaire. However, the number of questionnaires filled out by car commuters was not sufficient for our survey.

Workplace interviews will usually obtain information on the home location of each worker and characteristics of the household. This type of interview also collects information about how the employees travel when going to work. If the employer strongly supports the survey, it is often possible for the researcher to achieve very high response rates. If employers tell employees to complete the surveys in their own time, response rates are usually rather low whereas the

³⁸Hensher & Button (2000)

response rate tends to be higher if employees are permitted to fill out the form during “company” time³⁹.

By performing road-side interviews as a complement to workplace interviews, we were able to supplement the results obtained from the workplace interviews. In our road-side interviews, the driver was briefly interviewed and then he or she was allowed to proceed traveling. This type of survey may also be conducted by handing drivers a questionnaire to be completed and mailed back to the researchers. Road-side interviews are commonly used to find out about the traveler’s starting point and destination and to find out the number of people traveling in each vehicle at selected places in the urban area.

An alternative participatory survey that could have been used to measure commuters’ preferences and behavior is the intercept survey method. In this type of survey, travelers are intercepted while carrying out an activity of direct interest to the surveyor. Intercept surveys may be conducted at bus stops, train stations, and airport lounges. In the general case, an intercept survey is conducted by asking travelers to answer certain questions when they are waiting, for example, for the bus at the bus station. In our case, the developed questionnaire took about five to ten minutes to fill out, which made it inappropriate to ask people at bus and train stations since there was an obvious risk that the people would not have enough time to fill it out before entering a train or bus⁴⁰.

In summary, when conducting our survey we used a participatory non-household survey, which was divided into on board interviews, workplace interviews, and road-side interviews.

3.2.5 Stated Preference Experiment

Revealed Preference versus Stated Preference Experiment

Usually, infrastructure investments are very expensive and thus these types of investments need to be carefully evaluated. Therefore, it is of great importance to learn about commuters’ preferences when collecting data for transport

³⁹ Hensher & Button (2000)

⁴⁰ IBID

modeling. Traditionally, travel choice models are based on data collected by direct observation of travel behavior or by asking travelers about their actual travel behavior. The data collected through these procedures are called revealed data. However, the revealed data has some restrictions, which limit its suitability. Firstly, revealed data cannot be used in a direct way when evaluating the demand under conditions that do not exist. That is, revealed preference data is not appropriate to use when estimating the demand for different possible infrastructure investments. Secondly, one might experience difficulties in obtaining sufficient variation in the revealed data to analyze all variables of interest. Thirdly, there is a risk that there are strong correlations between explanatory variables of interest such as traveling time and cost. These correlations may complicate the estimation of model parameters that reflect the proper trade-off ratios. In cases where one cannot use revealed preference data, such as in the case of R45 and Norge/Vänernbanan, one often uses stated preference data. This type of data can be collected through surveys where the researcher provides the respondents with hypothetical choice situations. The respondents are asked to state their preference, such as their choice of transportation mode, in hypothetical situations, and thereby it is possible to handle completely new choice situations. However, an important prerequisite for using stated preference experiments is that the respondents are able to handle hypothetical situations⁴¹.

Design of a Stated Preference Experiment

To design a stated preference experiment entails selecting variables (factors) and values (levels) that these variables should have in the alternatives, which the respondents will face. The designs that are commonly used are orthogonal, which means that the variables, such as price and traveling time, vary independently. That is, the variables are uncorrelated. In orthogonal designs, the respondent may be faced with alternatives that provide a lower standard and at the same time are more expensive, such as a lower mode frequency at a higher price. In order to avoid unrealistic choices, the requirement of a complete orthogonal design is often relaxed.

⁴¹ Polak & Heertje (2000)

The number of alternatives included in the stated preference experiment is dependent on the number of factors that should be studied, the number of levels that these factors have and how many interactions should be identified. Interactions occur when the valuation of one factor is dependent on the level of another. For example, one may study the effect of the length of the traveling time and the importance of comfort. It is logical to think that the valuation of the traveling time is affected by the comfort. The longer the traveling time, the more important is the comfort. A design where one studies all possible interactions between the included variables may be very complicated and may involve a large number of different combinations between variables and factors. We have chosen not to study the interactions between time and frequency; instead time and frequency are studied separately, and hence are independent in our survey.

When constructing a stated preference experiment it is important to be aware of the fact that too many variables and levels will make it very complicated for the respondent to answer the questions. The exact number of alternatives that the respondent will manage to answer is greatly dependent on the structure of the questionnaire, the complexity of the variables and the motivation of the respondent in answering the questions. Generally, an accurate selection of factors to include in the stated preference experiment is made by considering the following requirements:

- The factors must be probable and intelligible
- The levels should be connected to the experience of the respondent
- It must be probable to vary the factors simultaneously
- The levels must enforce an adjustment / balance – even if the values vary in the sample.

The probability and the intelligibility of the factors are the most important characteristics of accurately selected factors. If the respondent experiences the alternatives that are presented as improbable, there is a risk that the respondent will not answer the questionnaire seriously. This behavior may, for example, occur in a situation where the standard of a certain bus trip in terms of certain factors, such as comfort and mode frequency, is too high with respect to the

price of the bus trip. In order to secure the probability and intelligibility of the stated preference experiment, pre-studies should be conducted.

The levels of the factors could be given absolute or relative changes. The choice of stating the levels of the factors in relative or absolute terms is dependent on which of these is most suitable for the specific experiment. There is no absolute rule for how many factors and levels to include in the stated preference experiment. However, the experience from other stated preference experiments says that it is recommended to use at most five factors. The same recommendations can be applied when discussing the optimal number of levels. However, when deciding on the number of levels one must consider whether the factors are continuous, such as price, or discrete, which means that only a certain numbers of values are possible. For continuous variables, the number of levels is less critical, but for discrete variables it is recommended to include not more than three to four levels. In our stated preference experiments, we used absolute changes in the traveling time and in the mode frequency. We found it appropriate to use six different alternatives each for car, bus, and train when analyzing the traveling time. Furthermore, the absolute changes in the traveling time had two different levels for car and bus but three levels for train. When analyzing the effect of changes in the mode frequency, we found it interesting to include eight different alternatives each for car, bus, and train. For car, the frequency was kept at the same level in all alternatives whereas the mode frequency for bus and train had three different levels. We found the number of alternatives and levels in our experiments appropriate to use since they seemed probable when studying the current conditions regarding the traveling time and the mode frequency on R45 and on Norge/Vänernbanan.

A stated preference experiment can be conducted in several ways. The respondent could rank the alternatives, rate the different alternatives or choose between the alternatives. Ranking is advantageous in the way that the respondent is faced with all alternatives at the same time. However, a disadvantage is that the respondent's decision situation is not similar to the choice situation in real life. In our case, ranking was used when the respondents were asked to decide the importance of certain factors in relation to each other. Rating means that each alternative is considered separately. Each alternative is

graded separately on a numeric or verbal scale. If the number of alternatives is large, problems of consistency may occur, which means that the respondent may not have the same scale of measure when rating the first and the last alternative. Rating questions are considered to provide a lot of information about the respondent, but it is not clear how valuable this information is since it has been shown that when converting rating results into ranking results, the results tend to be very similar. Discrete choice methods, which we decided to use, are very simple, in particular if the respondent only needs to choose between two alternatives. The discrete choice method is realistic since it is similar to real situations. However, when conducting a stated preference experiment by using the discrete choice method one should be aware of the fact that it could be very monotonous to fill out the alternatives⁴².

3.2.6 Development of the Questionnaire

In total, the questionnaire consisted of 30 questions, which were developed with respect to the choice based sample and the selected survey methods. Of the 30 questions, 13 questions were conducted by using stated preference experiments where the respondent had to make a choice between bus, train and car, given a certain situation. The first six questions were concerned with what mode of transportation commuters would choose if the actual traveling time for bus, train and car varies. The other seven questions were concerned with what mode of transportation commuters would prefer if the mode frequency for bus and train varies. In addition to the discrete choice method, we also used the ranking method for two questions. In these two questions, the respondent was asked to rank the factors comfort, speed, cost in monetary terms, mode frequency, waiting time, few stations and accessibility in order of importance. In this case, number one was the most important factor and number seven was the least important. In addition to the discrete choice and ranking questions, we constructed 17 questions focusing on socioeconomic characteristics.

The questionnaire was developed through valuable advice and comments from our tutor Göran Bergendahl and from Fredrik Carlsson, doctoral student at the department of Economics at School of Economics and Commercial Law, Göteborg University. After a first revision of our questionnaire draft, the

⁴² Widlert (1992)

questionnaire was tested on a number of people. We tested the questionnaire in order to make sure that the questions were easy to understand and that the questions measured what they were intended to measure. The testing of the questionnaire resulted in a few small changes. On our first bus trip to Trollhättan, we discovered that the commuters had difficulties in answering some of the questions, and therefore the questionnaire was revised again. Finally, we constructed the questionnaire that was used in our survey. This questionnaire was used on buses and trains and was sent out by e-mail to employees at a number of workplaces situated near R45 and Norge/Vänernbanan.

Out of the 30 questions included in the extensive questionnaire, we selected six questions that were used when performing the road-side interviews. When deciding which questions to ask the drivers, we considered the time aspect carefully. It was only possible to detain the drivers for a short period of time. Furthermore, we thought that the drivers might not answer the questions carefully if there were too many questions. Therefore, we decided to exclude the stated preference questions since they require rather much time.

The full questionnaire is presented in Appendix II and the short version of the questionnaire is presented in Appendix III.

3.2.7 Data collected through Survey

When performing our survey, the aim was to get 50 complete questionnaires each from car commuters, bus commuters, and train commuters. According to Fredrik Carlsson, a minimum number of 50 respondents within each transportation mode was required in order to statistically secure the results. In total, our data consisted of 167 completed questionnaires. Of the total number of questionnaires, 50 were from bus commuters, 50 from train commuters and 67 from car commuters. The 67 car commuters were divided into two groups, Car 1 and Car 2. Car 1 included the car commuters answering the questionnaire through workplace interviews whereas Car 2 included car commuters who were interviewed through road-side interviews.

On Board Interviews

In order to distribute the questionnaires to those who were commuting from home to work or from work to home by using public transportations, we traveled with buses and trains early in the morning and late in the afternoon. Before distributing the questionnaire to a potential respondent, we asked him or her if he or she regularly commuted to work. People who did not regularly commute to their work were not included in the survey. In total, three round trips were made with bus and two round trips were made with train. We traveled both from Göteborg to Trollhättan and from Trollhättan to Göteborg. A sample of 66 bus commuters was needed in order to get 50 complete questionnaires. To get 50 complete questionnaires from train commuters, we had to ask 57 commuters to fill out the questionnaire.

Workplace interviews

Our survey included employees at SAAB, Volvo Aero and kommunledningskontoret in Ale municipality. A sample of 20 commuters was needed in order to get 17 complete questionnaires.

Road-side Interviews

The road-side interviews were conducted through the help of the traffic police in Västragötalandsregionen. The interviews were performed on two different occasions, one early in the morning and one late in the afternoon. These locations were chosen by the police and we had no influence over their choice of location. By performing the road-side interviews early in the morning and late in the afternoon, it was possible to catch the commuters on R45. Our survey took place when the traffic police randomly stopped cars in order to inspect the drivers' driving licenses and the drivers' sobriety. After inspecting and testing the drivers, the police asked the driver if he or she regularly commuted on R45. If the driver answered yes, the police asked if he or she was willing to participate in a survey regarding the driver's commuting behavior. By letting the police ask these questions, we could be sure that the respondents were relevant to our survey. In total, a sample of 56 Car 2 drivers was needed in order to get 50 complete questionnaires.

3.2.8 Sources of Errors when collecting Data for a Stated Preference Experiment

The collection of stated preference data is more difficult than the collection of revealed preference data. Different sources of error that may occur when using the stated preference method and the revealed preference method are presented below:

Type of Error	Stated Preference Method	Revealed Preference Method
Errors in choice of sample	X	X
Fall-offs	X	X
Information reported	X	X
Absence of restrictions	X	
Confirmation	X	
Rationalization	X	
Policy answer	X	

Source: Widlert (1992)

Table 3.1

Errors in Choice of Sample

The sample for our survey was selected very carefully in order to be certain that all respondents were of interest to our survey. Furthermore, we believe that the survey methods used are appropriate when performing a survey among bus, train, and car commuters. As previously mentioned, household travel surveys are the primary surveys for transport modeling. However, if this survey method had been used, it would have been far more complicated to catch commuters using R45 and Norge/Vänernbanan, and hence we would have had a higher risk of errors in our sample.

Fall-offs

We can conclude that the number of fall-offs among bus commuters was higher than among train commuters since a sample of 66 bus commuters was needed to get 50 complete questionnaires whereas a sample of only 57 train commuters was required to get 50 complete questionnaires. Several studies have shown that elderly people or people who have a lower level of education have more difficulties in answering the questions than young people with a higher level of

education. This may lead to fall-offs and a lower quality of information reported⁴³. A survey made by SIKA concludes that people with a low level of education tend to travel by bus to a larger extent than people with a higher degree of education⁴⁴. These arguments may explain why we had to use a larger sample among bus commuters than among train commuters in order to get 50 complete questionnaires within each commuting group. The number of fall-offs among Car 1 commuters and Car 2 commuters was lower than among bus commuters. The fall-offs amounted to three people in our workplace interviews, which means that a sample of 20 people was required in order to get 17 complete questionnaires. Furthermore, the road-side interviews required a sample of 56 car commuters. Among the fall-offs in the road-side interviews, one driver was not even asked to fill out the questionnaire since he received a fine for speeding. The remaining five drivers who did not answer our questionnaire said that they did not have the time to fill out the questionnaire. There were no fall-offs among the drivers who completed the questionnaire since we were able to help the drivers if they had any questions while filling out the questionnaires.

Other Types of Errors

The stated preference method may entail further errors, which are caused by the fact that we are interested in what the respondent says he or she will do and not what he or she actually does. In stated preference experiments, it is difficult to capture all the restrictions that are considered when the respondent makes the choice in real life. Furthermore, a respondent may feel that he or she is expected to answer in a certain way. That is, he or she may think that there is an answer that is more correct than the others. This error is defined as an error of confirmation. In our workplace interviews, some of the respondents who commuted by car to Ale municipality chose the train in our discrete choice experiments, but at the same time they said that a train station in Ale municipality would not affect them. This behavior may indicate that these respondents chose the train because they thought that it was more correct to choose train than car because, for example, a train is better for the environment. However, these commuters will probably continue commuting by car even if

⁴³ Widlert (1992)

⁴⁴ www.sika-institute.se (251003)

the Norge/Vänernbanan investment is made since they stated that a train station in Ale municipality would not affect them.

Another problem that may arise is that the respondent tries to rationalize the choices made and therefore tends to overestimate the advantages and the probability of selecting a certain alternative. These errors may occur when using the revealed preference method, but it is more common in a stated preference experiment. Finally, the respondent in a stated preference experiment may give policy answers, which means that the respondent wishes to influence a decision to be made. For example, if policy makers are considering closing a train station, the respondent may have incentives for overestimating his or her use of the train station in question if the respondent does not want the train station to be closed down. The errors discussed above tend to be smaller if the respondent is asked to evaluate certain situations but larger if the respondent is asked to choose between alternatives. In our case, bus commuters may have overestimated the advantages of commuting by train and how they would be affected by a train station in Ale municipality since they favor a train station in Ale Municipality⁴⁵.

3.2.9 Choice of Variables in Limdep and their Significance

Choice of Variables

To evaluate the effects of the commuters' socioeconomic characteristics, we included some of the questions covering these characteristics as variables when running the Limdep program. Due to restrictions in the Limdep program, we were advised to exclude some of our socioeconomic variables when running the program. We decided to exclude the following variables:

- Possession of a driving license
- Number of days working at home
- Number of days per week that the commuter drove to work
- Use of car to reach a train or bus station when going to work
- The current frequency of the commuter's transportation mode
- Effect of a train station in Ale municipality on the commuter

⁴⁵ Widlert (1992)

We excluded possession of a driving license since we thought that car access was a more relevant variable to use. For example, one may have a driving license, but still have no car access. The number of days per week that a commuter worked at home was not included since we believe that the question regarding the commuter's influence on working hours would be able to catch similar behavior patterns. We found that car access was a more important variable than the number of days per week that the commuter drove to work and the use of a car to reach a train or bus station when going to work since car access is a prerequisite for these two questions. The current frequency of the commuters' transportation mode was not included because we believe that relevant information regarding the mode frequency is better captured in the discrete choice experiments with respect to the mode frequency for bus and for train. It would have been interesting to include the effect of a train station in Ale municipality on the different commuters in the Limdep program, but since we discovered irrational answers among some car commuters we decided to exclude this variable.

We found the socioeconomic variables that are not discussed above to be appropriate to include in the Limdep program. These variables are presented below:

- Starting point
- Destination
- Car access
- Traveling time to work
- Main reason why the commuter decided to go by car, bus, or train
- Possibility to affect working hours
- Gender
- Age

One should be aware of that by traveling time to work we mean the actual traveling time. That is, the total traveling time from door to door.

Significance of Variables used in Limdep

In our analysis, we used a significance level of 0,05 since this level is commonly used in transport modeling⁴⁶. The variables of starting point, traveling time, gender, age, and the possibility to affect working hours had a significant effect on the probability of choosing car with respect to changes in the traveling time. The variables that did not appear to have a significant effect on the probability of choosing car were car access and destination. Furthermore, starting point, gender, traveling time, and the possibility to affect working hours were also significant for bus when considering changes in traveling time. Additionally, destination also seems to have a significant effect on the probability of choosing bus when the traveling time changes. The insignificant variables for bus commuters were age and car access.

When using the same significance level for mode frequency as for traveling time, one can conclude that starting point, destination, traveling time, and gender seem to have a significant effect on the probability of choosing car. The insignificant variables for car with respect to changes in the mode frequency were age, the possibility to affect working hours, and car access. For bus commuters, starting point, destination, traveling time, age, and the possibility to affect working hours had a significant effect on the probability of choosing bus when considering changes in the mode frequency, whereas gender and car access did not.

When using the Limdep program, one must use one of the transportation modes as a reference. The reference requirement cannot be relaxed since the Limdep program requires such a reference in order to calculate elasticities and cross elasticities. In our case, train was the reference mode. The program uses this reference when calculating the significance levels of the different variables when traveling by car or bus, but since train is used as a reference, the program is not able to produce the significance levels of the variables when traveling by train. The significance levels for all variables when traveling by car or bus can be found in Appendix IV and in Appendix V. Appendix IV presents the Limdep output when analyzing the effect of changes in the traveling time

⁴⁶ Fredrik Carlsson (151003)

whereas Appendix V shows the Limdep output when analyzing changes in the mode frequency.

3.2.10 Descriptive Statistical Approach

In order to present and analyze the questions that were not included in the discrete choice experiment, we used a descriptive statistical approach. A descriptive statistical approach means that the results from the questions asked are presented in graphs and tables. The reason for using a descriptive statistical approach is that one easily gets an overview of the results obtained.

3.2.11 Additional Approach

Except for the procedures discussed above, we also used our results from the discrete choice experiments in order to describe how one can use a scenario analysis in the field of transportation when estimating the demand for different modes. Through this kind of analysis one is able to capture possible uncertainties about the future in different scenarios. Thereby, one can foresee which investments may be required and also be prepared for how the demand for transportation may react to different infrastructure investments.

3.3 Qualitative Approach

3.3.1 Interview Sample

In order to get the opinion from all geographical areas between Göteborg and Trollhättan we interviewed companies in all municipalities in the area. The sample consisted of seven companies, of which six companies were selected because of their size. The companies were required to have at least 50 employees and a constant flow of goods. These requirements were set up in order to select companies that were able to give relevant answers to our questions. We chose two companies among the five largest companies in the municipalities of Göteborg and Trollhättan. In the municipality of Ale, one company of the five largest in the municipality was selected. We followed the same procedure when selecting a company in Lilla Edet. One company, SKF, was selected not because of its size, but because of its location in Gamlestan, Göteborg. SKF is located in an area where many infrastructure investments are planned. Accordingly, we found it interesting to study how the company would be affected by possible infrastructure investments in R45 and

Norge/Vänernbanan. The companies that we interviewed are presented in the table below:

Municipality of Ale	Municipality of Lilla Edet	Municipality of Göteborg	Municipality of Trollhättan
Eka Chemicals AB, 800 employees	SCA, 500 employees	AB Volvo, 25,400 employees	SAAB Automobile, 7,600 employees
		SKF, 4,800 employees ⁴⁷	Volvo Aero Corporation, 4,500 employees
		Volvo Car Corporation, 27,380 employees	

Table 3.2

Limitations

We have restricted our interviews to include some of the largest companies in each municipality. There also exists a wide range of smaller companies in these municipalities and we are aware of the fact that smaller companies' use of R45 and Norge/Vänernbanan and their views on investments in the area may differ from the larger companies' use and need for infrastructure investments.

3.3.2 Interview Guide

The interviews were performed in order to map the companies' flow of goods and also to discuss their employees' commuting situation. Furthermore, the aim was to learn about how the companies could be affected by an investment in R45 and Norge/Vänernbanan in terms of flow of goods, recruiting, and employees' commute. An interview guide covering the areas of interest was distributed to the company before the interview was performed. The interview guide is presented in Appendix VI. With respect to the characteristics of the interview guide, we found it most appropriate to use a qualitative approach when analyzing our results.

3.4 Comparative Approach

In order to evaluate the demand for an infrastructure investment in Norge/Vänernbanan and to determine the optimal number of train stations between Göteborg and Trollhättan, we found it interesting to make

⁴⁷ www.skf.com (091203)

comparisons to Svealandsbanan in the Mälaren Valley. The comparative approach was appropriate since the two railways run parallel to an important regional road. Norge/Vänernbanan runs parallel to R45, whereas Svealandsbanan runs parallel to E20. The concentration of people and companies in Trollhättan and Göteborg in the case of Norge/Vänernbanan further strengthens the relevance of a comparison to Svealandsbanan since most people and companies are concentrated in Stockholm and Eskilstuna. By using a comparative approach, it was possible to evaluate the demand for an infrastructure investment in Norge/Vänernbanan from another perspective than the one used when analyzing the results from our survey and interviews.

3.5 Validity and Reliability of Our Survey and Interviews

Emroy and Cooper argue that a measurement tool can be considered of good quality if it is an accurate indicator of what one is interested in measuring⁴⁸. Additionally, the tool should be easy and efficient to use. In our thesis, the measurement tools used are the survey and the performed interviews. Validity and reliability are two major concepts that can be used when evaluating measurement tools. Therefore, these two concepts have been used when evaluating the quality of our survey and interviews.

3.5.1 Validity

Validity is defined as the absence of systematical errors of measurement. Validity could be divided into internal and external validity. Internal validity is concerned with to what extent the researcher is measuring what the researcher believes is being measured. Furthermore, internal validity also is concerned with whether the measurement used captures reality in an appropriate way⁴⁹. The external validity, on the other hand, deals with the relationship between the researcher's result of the measured object and reality. A high level of external validity could be reached if the researcher's results are applicable to similar situations⁵⁰.

The internal validity of our survey should be rather high since we tested the questionnaire on a number of people before performing our survey. The pre-

⁴⁸ Emroy and Cooper (1991)

⁴⁹ Merriam (1998)

⁵⁰ Patel & Davidsson (1994)

testing of the questionnaire resulted in changes since some questions did not measure what we intended to measure. A weakness with our survey is that we have not defined the concepts of comfort and accessibility in the questionnaire. These two factors may mean different things for different commuters, which may have a negative effect on the internal validity. The internal validity will be negatively affected in the sense that we may not measure what we intend to measure regarding accessibility and comfort.

It is difficult to determine whether one can generalize our results to other roads and railways in Sweden since we are not familiar with the prevailing conditions on these other roads and railways. Therefore, it is hard to determine the external validity of our study.

Another aspect of validity is content validity, which is defined as the extent to which a measuring instrument provides adequate coverage of the topic under study⁵¹. Whether our survey and interviews included the correct questions is hence a question of content validity. Accordingly, the degree of content validity is largely dependent on the questions asked in the questionnaire and in the interview guide. In order to achieve a high degree of content validity, we performed an extensive literature review concerning infrastructure investments and the current conditions on R45 and Norge/Vänernbanan before the questionnaire and the interview guide were developed. Furthermore, we also tested the questionnaire on a number of people before the actual survey was undertaken.

3.5.2 Reliability

The reliability of our survey, as well as the reliability of the interviews, is dependent on to what extent our results and conclusions can be replicated by another researcher. Accordingly, one can say that our survey and interviews are reliable if they supply consistent results. One way of measuring the reliability is to consider the sample size of the survey and the interviews. A large sample will affect the reliability positively⁵². In our survey, we used the minimum required sample for each commuting group, that is, 50 commuters within each

⁵¹ Emroy & Cooper (1991)

⁵² IBID

group. According to Emroy and Cooper, our small sample will have a negative effect on the reliability⁵³. Furthermore, through our workplace interviews we were not able to collect 50 complete questionnaires, which could affect the reliability negatively. However, we compensated for the low number of car commuters by giving the three groups of commuters (train, bus, and car) different weights when running the Limdep program. Furthermore, we performed road-side interviews to get a larger sample of car commuters in some of the questions asked. We can conclude that the results from our workplace interviews are very similar to the results obtained by the road-side interviews. We believe that the consistency between Car 1 and Car 2 commuters would have a positive effect on the reliability.

When performing the company interviews, we used a sample of seven companies that were selected because of their size and flow of goods. The sample size could have been larger, but due to time constraints we decided to only include seven companies. We believe that the fact that our sample includes companies from all municipalities located in the area along R45 and Norge/Vänernbanan between Göteborg and Trollhättan affects the reliability in a positive way. Other factors than the sample size may, however, affect the reliability of a survey in a negative way. Low reliability could be caused by the observer, the way the measure is administered, the participant, or a combination of these three. Generally, it is very difficult to determine the source of a measure's lack of reliability⁵⁴.

The reliability of the survey and of the interviews will affect the quality of our analysis. We believe that the quality of our analysis is positively affected by not including questionnaires where more than one question was incomplete when running the Limdep program and when performing our descriptive statistical analysis. In total, there were eight questionnaires where one question was incomplete. However, one factor that could affect the quality of our analysis in a negative way is concerned with the construction of the stated preference questions in our survey. The alternatives in our questions are based on absolute changes in the traveling time or in the mode frequency. A

⁵³ Emroy & Cooper (1991)

⁵⁴ Yin (1994)

drawback when using absolute changes in traveling time is that the absolute change in the traveling time affects commuters differently, depending on their current traveling time to work. In our case, a ten minute reduction in the traveling time could, for example, affect a person who is commuting between Göteborg and Trollhättan differently than a person who is commuting between Lilla Edet and Trollhättan. We decided to use absolute changes when constructing our survey even though we were aware of this drawback when constructing our survey, since relative changes are considered to be more complicated to complete in a questionnaire and hence probably would have resulted in a larger number of fall-offs. Furthermore, Fredrik Carlsson suggested us to use absolute changes since he believed that the difference in commuters' distance to work when analyzing the distance between Göteborg and Trollhättan should not affect the analysis in a major way.

4 SURVEY AND INTERVIEW RESULTS

4.1 Results from Survey

We will present the results from our survey in two different parts. The first part concerns socioeconomic factors, such as gender and age, but it also concerns a few other factors, such as the reason for choosing a specific mode. The second part presents the results obtained when using the multinomial logit model.

4.1.1 Results from Descriptive Statistical Approach

As can be seen in table 4.1, there is a larger percentage of men traveling by train and by car than women. However, the results show that there is a larger percentage of women traveling by bus than men. When looking at all modes together, we can conclude that 46% of the commuters who we interviewed were women and that 54% were men.

Mode	TRAIN	BUS	CAR 1	CAR 2	ALL MODES
Gender	% of train commuters	% of bus commuters	% of car commuters	% of car commuters	% of all commuters
Woman	44%	66%	41%	30%	46%
Man	56%	34%	59%	70%	54%

Table 4.1

The results from our survey show that the commuters who we have interviewed mainly represent two different age groups, which are 25-44 and 45-64 (table 4.2). The oldest age group is only represented by 2% of Car 2 commuters. The youngest age group is represented in two of the transportation modes, which are bus and Car 2.

Mode	TRAIN	BUS	CAR 1	CAR 2
Age	% of train commuters	% of bus commuters	% of car commuters	% of car commuters
18-24 years	0%	20%	0%	4%
25-44 years	66%	50%	53%	56%
45-64 years	34%	30%	47%	38%
65 years or older	0%	0%	0%	2%

Table 4.2

Table 4.3 shows the percentage of commuters who have a driving license and car access in each respective transportation mode. As one can see, train commuters in our survey both more commonly have driving licenses and car access than bus commuters. As expected, both Car 1 and Car 2 commuters all have driving licenses and car access.

Mode	TRAIN	BUS	CAR 1	CAR 2
Driving license	% of train commuters	% of bus commuters	% of car commuters	% of car commuters
Yes	88%	66%	100%	100%
No	12%	34%	0%	0%
Car Access				
Yes	72%	48%	100%	100%
No	28%	52%	0%	0%

Table 4.3

When asking whether the respondents ever work at home in order to avoid commuting to work, we can observe that Car 1 commuters are the most likely to work at home whereas bus commuters seldom work at home (see table 4.4). The majority of train commuters and bus commuters and all Car 1 commuters are able to influence their working hours. Furthermore, train commuters can influence their working hours to a larger degree than bus commuters. Car 2 commuters did not answer the two questions discussed since these questions are not included in the short version of our questionnaire.

Mode	TRAIN	BUS	CAR 1	CAR 2
Working at home	% of train commuters	% of bus commuters	% of car commuters	% of car commuters
Yes	42%	16%	59%	NA
No	58%	84%	41%	NA
Influence over working				
Yes	88%	60%	100%	NA
No	12%	40%	0%	NA

Table 4.4

Question 10 in the full questionnaire asks the respondents to state their main reason for choosing the specific transportation mode that they usually commute with when going to work. Question 10 was divided into parts a, b, and c where a was supposed to be filled out by car commuters, b by bus commuters, and c by train commuters. The alternatives in a, b, and c differed slightly depending on which transportation mode the respondent normally used. Train commuters could choose between the following reasons:

- My fastest alternative
- My cheapest alternative (in monetary terms)
- My most comfortable alternative
- There are no suitable bus connections to my work
- I have no car access

As can be seen in chart 4.1, the most common reason given for commuting by train was that it was the most comfortable alternative. Furthermore, many train commuters who we interviewed said that they chose train because it was their fastest or cheapest alternative. It is also worth noticing that no respondent stated that there were no suitable bus connections to their work. Chart 4.1 shows that 2% consisted of incomplete answers, which in this case corresponds to one commuter who told us that she went by train to be able to work during her traveling time.

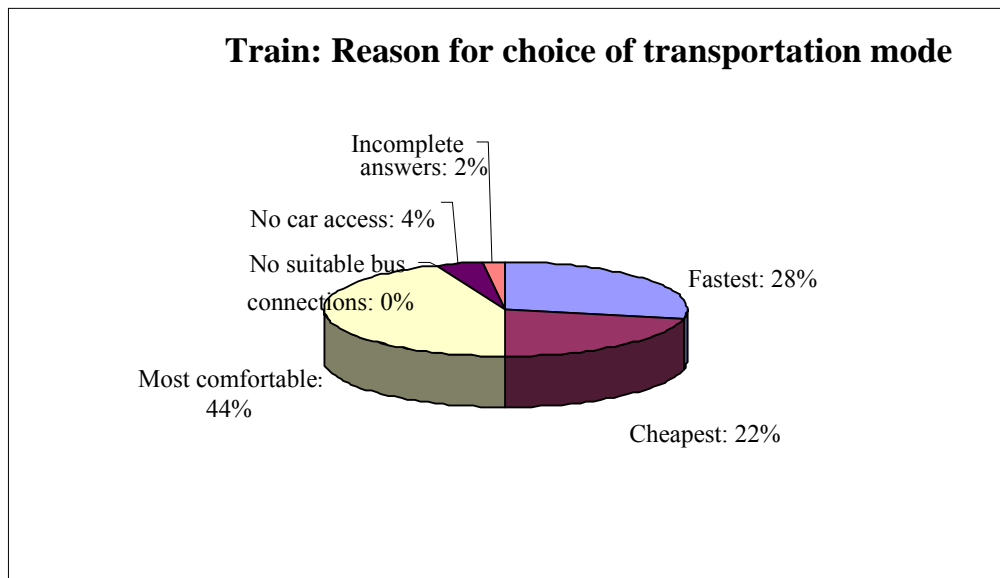


Chart 4.1

Bus commuters could choose between the following alternatives:

- My fastest alternative
- My cheapest alternative (in monetary terms)
- My most comfortable alternative
- No suitable train connections to my work
- No car access

When comparing the answers from bus commuters, which are described in chart 4.2, and the answers from train commuters, one can see that the reasons for choosing a specific transportation mode differ between bus and train commuters. For example, approximately one third of the bus commuters chose no car access as their main reason for commuting by bus whereas train commuters very seldom chose this alternative. Furthermore, very few bus commuters (8%) chose fastest as their reason for choosing bus while 28% of the train commuters chose this alternative. Two of the most common reasons for choosing bus are most comfortable and cheapest. The results for bus commuters also contained 2 % incomplete answers and these 2% result from one person who did not answer the question.

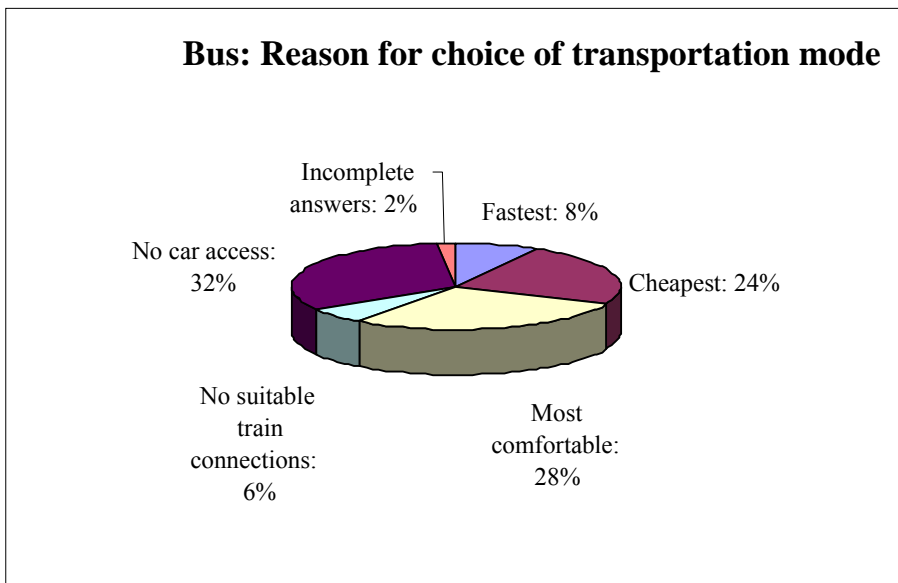


Chart 4.2

Both Car 1 and Car 2 commuters could choose between the following reasons:

- My fastest alternative
- My cheapest alternative (in monetary terms)
- My most comfortable alternative
- No suitable train-or bus connections to my work
- No public transportation alternatives

Chart 4.3 presents the results from Car 1 commuters. One can conclude that the vast majority (82%) of Car 1 commuters chose fastest as their main reason for driving to work. Two alternatives, cheapest and no public transportation alternatives, were not selected as the main reason for commuting by car to work.

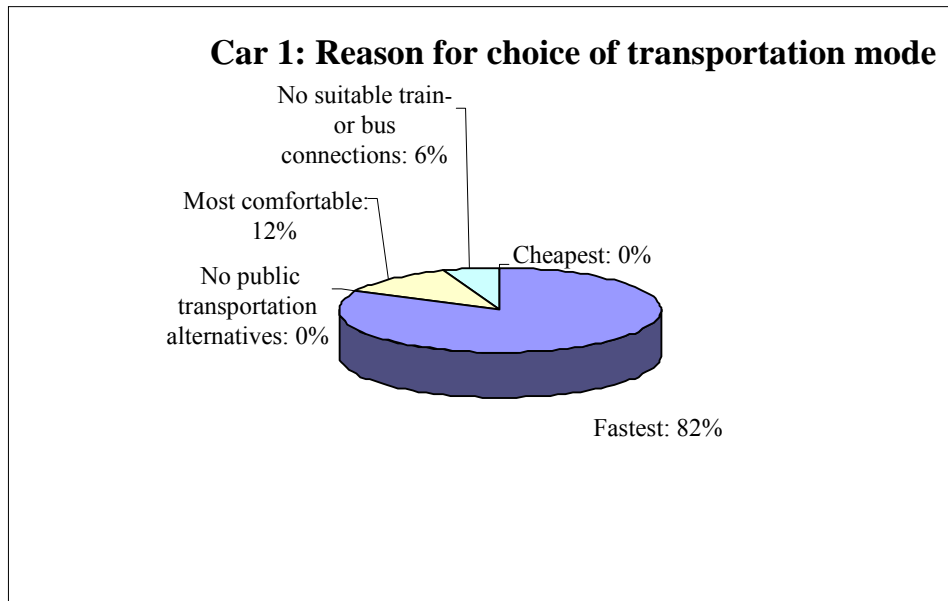


Chart 4.3

Question 10a was also included in the short version of the questionnaire, but is referred to as question 2. Among Car 2 commuters (see chart 4.4), the most common reason for choosing car is that it is the fastest alternative (56%), which is the same alternative that Car 1 commuters most often chose. However, among Car 2 commuters the alternative fastest is only chosen by 56% of the respondents compared to 82% among Car 1 commuters. Another similarity between Car 1 and Car 2 commuters is that no respondent chose cheapest as their main reason for commuting by car. Another interesting fact is that 4% of Car 2 commuters state that there are no public transportation alternatives for them when going to work. In contrast to the results from Car 1, the results from Car 2 commuters show 12% incomplete answers. These 12% consists of 6 commuters who said that their main reason for commuting by car is that they are required to use a car in their work. Since our questionnaire did not cover this reason, we told them to add this alternative to the question.

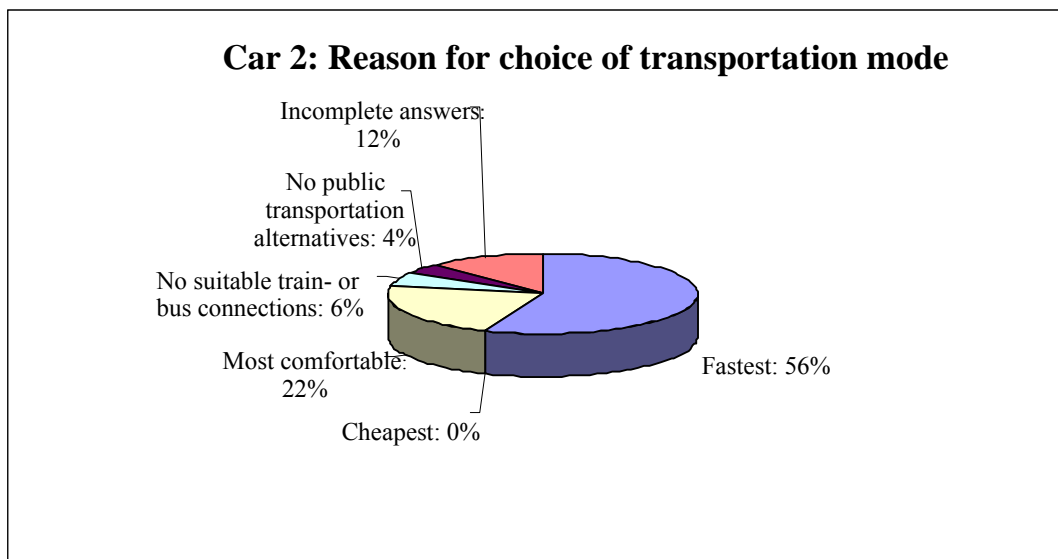


Chart 4.4

Table 4.5 shows the average traveling time among the commuters for train, bus, and Car 1. The short version of the questionnaire did not include a question where the respondents were supposed to record their traveling time and hence this question is not applicable to Car 2 commuters. Table 4.6 presents the average distance to work for all types of commuters. As one can see, bus commuters have a longer average traveling time than Car 1 commuters even though they, on average, travel a shorter distance. The average traveling time and the average distance to work are included in our multinomial logit model, but are not further analyzed in the following chapters.

Mode	Average traveling time to work (hours)
Train	1,47
Bus	1,00
Car 1	0,76
Car 2	NA

Table 4.5

Mode	Average distance to work (km)
Train	78,0
Bus	28,7
Car 1	48,5
Car 2	32,1

Table 4.6

By asking the respondents for their starting point and their destination, one is able to determine how these commuters tend to travel within the specific area analyzed in our thesis. Table 4.7 shows the percentage of commuters who travel between certain municipalities. Among train commuters, 100% travel between Göteborg and Trollhättan or between Trollhättan and Göteborg. The largest percentage of bus commuters (80%), Car 1 commuters (47%), and Car 2 commuters (56%) travel between Göteborg and Ale or Ale and Göteborg.

Travel Distance	TRAIN	BUS	CAR 1	CAR 2
Gbg-Thn (Thn-Gbg)	100%	0%	35%	10%
Gbg-Ale (Ale-Gbg)	0%	80%	47%	56%
Gbg-Lilla Edet (Lilla Edet-Gbg)	0%	4%	0%	2%
Gbg-Kungälv (Kungälv-Gbg)	0%	0%	0%	8%
Thn-Ale (Ale-Thn)	0%	6%	12%	0%
Thn-Lilla Edet (Lilla Edet-Thn)	0%	4%	0%	0%
Thn-Kungälv (Kungälv-Thn)	0%	0%	0%	0%
Ale-Lilla Edet (Lilla Edet-Ale)	0%	0%	6%	0%
Ale-Kungälv (Kungälv-Ale)	0%	0%	0%	10%
Lilla Edet-Kungälv (Kungälv-Lilla Edet)	0%	0%	0%	12%
Ale-Ale	0%	4%	0%	2%
Lilla Edet-Lilla Edet	0%	2%	0%	0%

Table 4.7

To present further the results from the table above, we have created four different figures that show how different types of commuters tend to travel.

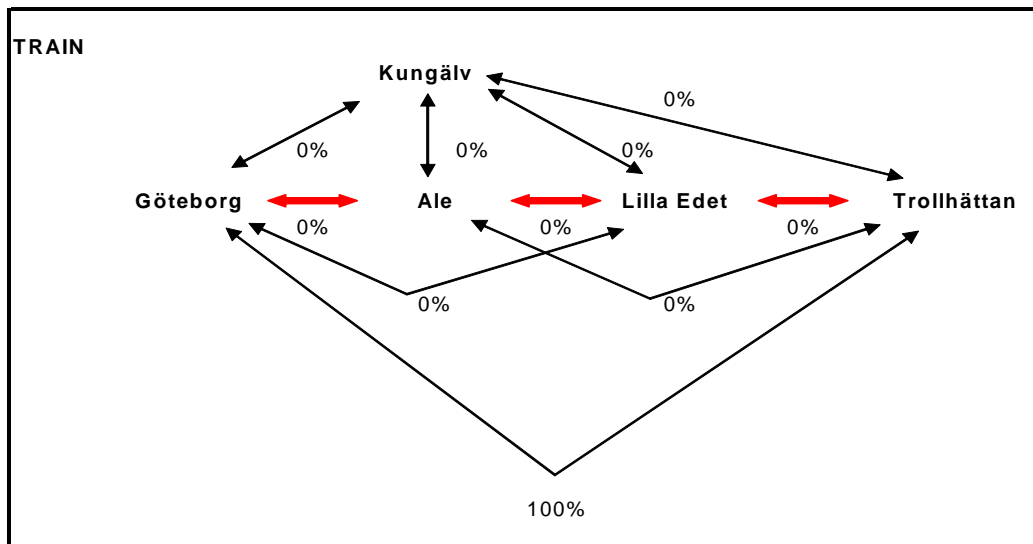


Figure 4.1

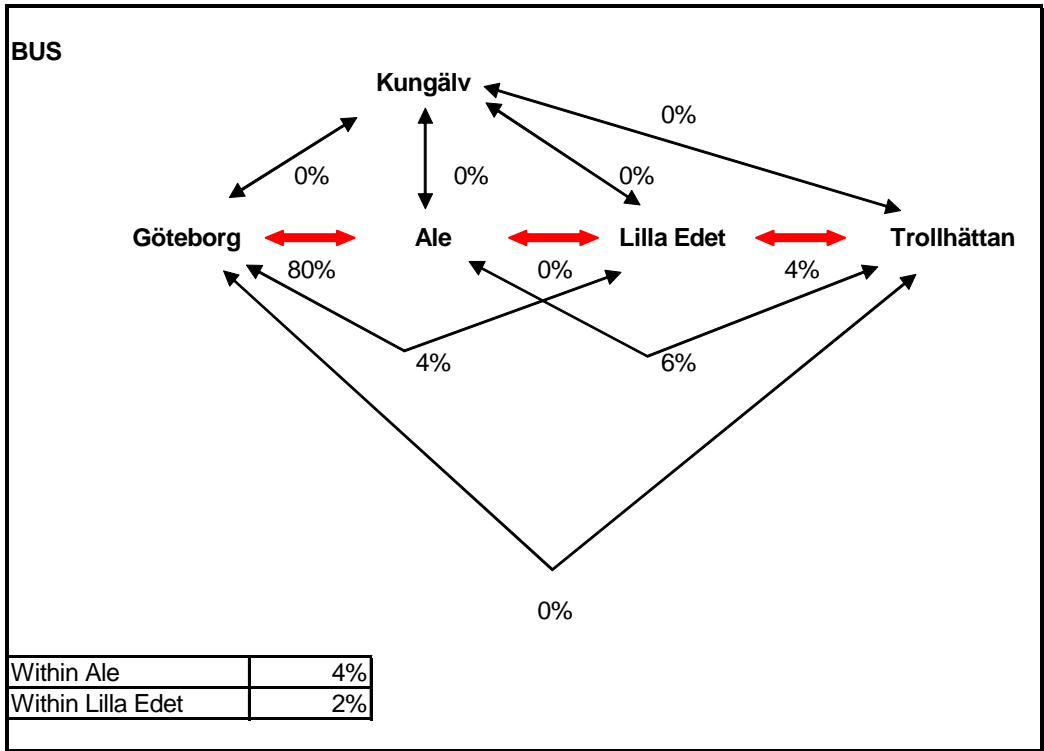


Figure 4.2

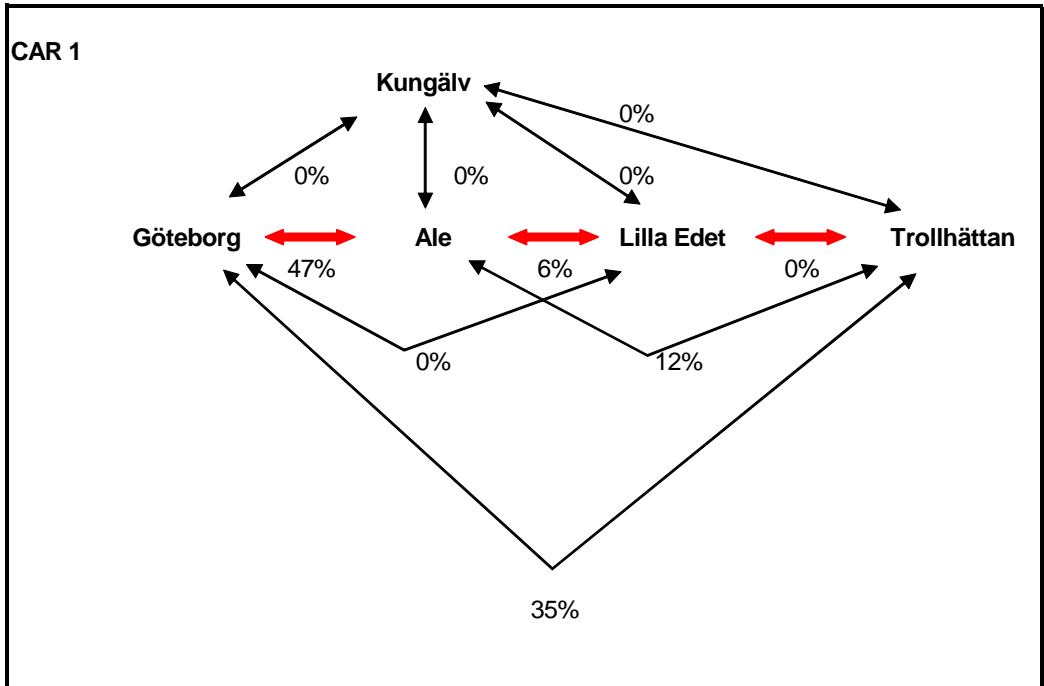


Figure 4.3

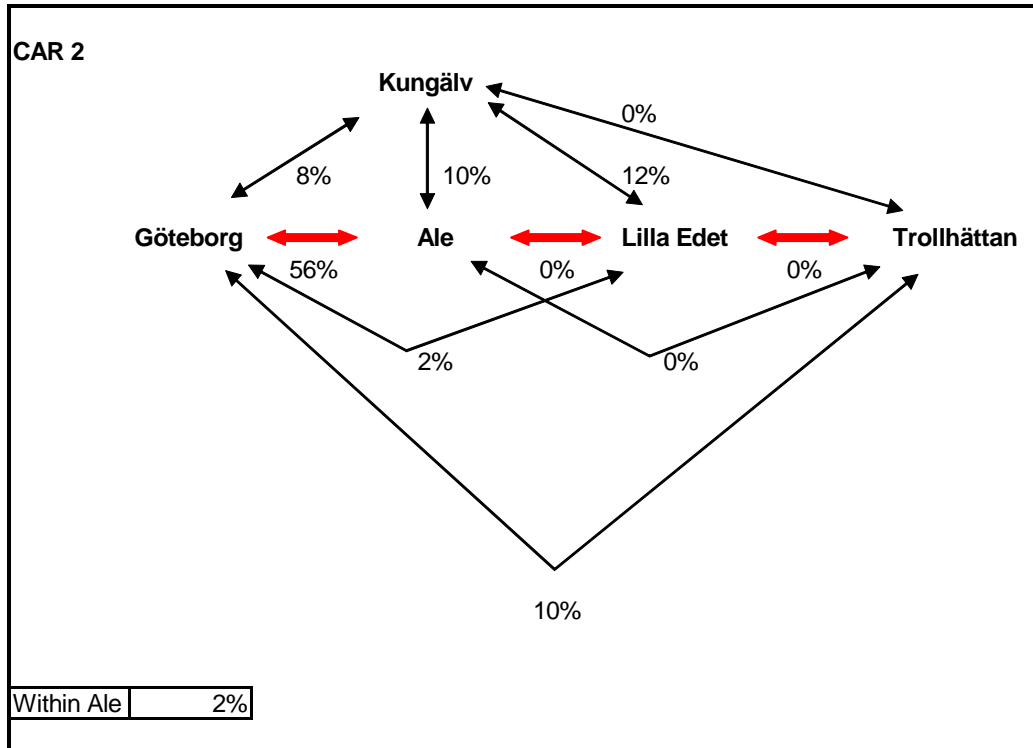


Figure 4.4

In questions 13 and 14 we were interested in the importance of different factors to commuters when traveling by train or bus. The factors that we asked the respondents to rank were comfort, speed, cost (in monetary terms), mode frequency, waiting time, few stations, and accessibility (for example, distance to train or bus station). We asked the respondents to rank these factors from 1 to 7 where 1 is the most important and 7 the least important. For train, we wanted to find the ranking among the commuters actually traveling by train and among possible train commuters (current bus and car commuters). For bus, we wanted to find the ranking among the commuters actually traveling by bus and among possible bus commuters (current train and car commuters). More specifically, in question 13, we asked all car, train, and bus commuters to rank these factors considering commuting by train and in question 14 we asked all types of commuters to rank these factors considering commuting by bus.

Tables 4.9 and 4.10 present the three most important factors when commuting by train (question 13). Speed seems to be a very important factor since it is one of the three most important factors for all types of commuters. Comfort is more

important for train and car commuters than for bus commuters. Both Car 1 and Car 2 commuters ranked accessibility as the most important factor while train and bus commuters say that speed is the most important factor. One can conclude that the ranking among actual train commuters (table 4.9) and those who do not currently travel by train (table 4.10) is similar in several ways. However, actual train commuters do not rank accessibility as one of their three top choices.

Actual train commuters

Ranking	TRAIN	
	Factor	% of sample
1	Speed	40%
2	Comfort	20%
3	Cost	14%

Table 4.9

Possible train commuters

Ranking	CAR 1		CAR 2		BUS	
	Factor	% of sample	Factor	% of sample	Factor	% of sample
1	Accessibility	29%	Accessibility	28%	Speed	44%
2	Speed	24%	Comfort	18%	Accessibility	22%
3	Comfort	18%	Speed	16%	Cost	16%
3	Cost	18%				

Table 4.10

The three most important factors when commuting by bus (question 14) are presented in table 4.11 and in table 4.12. One can observe that the factor mode frequency is only placed among the top three by actual bus commuters. Furthermore, one can observe that the two factors, speed and accessibility, are highly ranked by all types of commuters, both actual and possible bus commuters. The factor cost is included among the top three for all types of commuters except for Car 2 commuters. This relationship is also true for question 13 discussed above.

Actual bus commuters

Ranking	BUS	
	Factor	% of sample
1	Speed	34%
2	Cost	20%
2	Accessibility	20%
3	Mode frequency	10%

Table 4.11

Possible bus commuters

Ranking	CAR 1		CAR 2		TRAIN	
	Factor	% of sample	Factor	% of sample	Factor	% of sample
1	Accessibility	29%				
1	Speed	29%	Accessibility	28%	Speed	38%
2	Comfort	18%	Comfort	18%	Accessibility	18%
3	Cost	12%	Speed	16%	Cost	12%

Table 4.12

In our questionnaire we were also concerned with how a train station in Ale municipality would affect the different types of commuters. Table 4.13 illustrates the results from this question where one can see that of the four commuter types, bus commuters most often believe that they will be positively affected by a train station in Ale municipality. Train commuters, on the other hand, most often believe that they will be negatively affected by a train station in Ale municipality. Furthermore, car commuters more often say that they will not be affected by a train station in Ale municipality than other types of commuters.

Mode	TRAIN % of train commuters	BUS % of bus commuters	CAR 1 % of car commuters	CAR 2 % of car commuters
Nothing	48%	10%	59%	51%
Positively	8%	88%	35%	49%
Negatively	44%	2%	6%	0%

Table 4.13

4.1.2 Results from Multinomial Logit Model

As mentioned earlier, some of the questions in our questionnaire were constructed by using the discrete choice method. When constructing the questionnaire, we decided to focus on two important factors, traveling time and mode frequency, that influence people's choice of transportation mode. Appendix VII depicts to what extent different types of commuters chose train, bus, and car in our different alternatives with respect to changes in the traveling time and in the mode frequency. Tables 4.14, 4.15, and 4.16 present the elasticities for each type of commuter and different cross elasticities among the three different commuter types with respect to changes in traveling time. By change in traveling time, we mean how much the reduction in traveling time increases. That is, a further reduction in traveling time. Table 4.14, for

example, shows the elasticity among car commuters with respect to a change in the traveling time for car and the cross elasticities among bus and train commuters with respect to the change in traveling time for car. The elasticity among car commuters is higher than the elasticities among train and bus commuters. Furthermore, the largest cross elasticities were found when analyzing the effect of a change in traveling time for train. One can also observe that bus commuters have the lowest elasticity of the three types of commuters. When analyzing the different cross elasticities one should remember that the multinomial logit model always produces unitary cross elasticities.

Choice	Elasticity	Cross elasticities
Car*	0,501	
Bus		-0,171
Train		-0,171

Table 4.14

Choice	Elasticity	Cross elasticities
Car		-0,191
Bus*	0,258	
Train		-0,191

Table 4.15

Choice	Elasticity	Cross elasticities
Car		-0,556
Bus		-0,556
Train*	0,342	

Table 4.16

Table 4.17 and table 4.18 illustrate the elasticities and cross elasticities among each commuter type with respect to the change in mode frequency per hour for bus and train. The elasticity among bus commuters is larger than the elasticity among train commuters. An interesting observation is that the cross elasticities among car and bus commuters are larger than the elasticity among train commuters when considering the mode frequency for train.

Choice	Elasticity	Cross elasticities
Car		-0,517
Bus*	0,638	
Train		-0,517

Table 4.17

Choice	Elasticity	Cross elasticities
Car		-0,710
Bus		-0,710
Train*	0,445	

Table 4.18

4.2 Interview Results

As mentioned in section 3.1, we have conducted interviews with a selection of companies in order to understand their point of view about infrastructure investments in general and R45 and Norge/Vänernbanan in particular. Table 4.19 gives a summary of the people we interviewed, their positions, and which companies they represent.

Company	Name	Position
AB Volvo	Rune Landin	Public Affairs Manager
Eka Chemicals	Stefan Bodelind	Manager Transport Purchasing
SAAB	Anna Petre	Public Affairs Manager
SCA	Gunnar Johansson	Environment and Quality Manager
SKF	Kennet Jansson	Logistics Manager
Volvo Aero	Niklas Blom & Kent Mattelin	External Logistics Manager & Human Resource Representative
Volvo Car Corporation	Thomas Fleischer	Governmental Affairs Manager

Table 4.19

To summarize the answers from our interviews, we decided to present the results in seven different tables, tables 4.20-4.28, each focusing on a specific question. These tables are presented below.

How do you perceive employees' current commuting situation and could it be affected by infrastructure investments in R45 and Norge/Vänernbanan?

Company	R45 today	Norge/Vänernbanan today	Investment in R45	Investment in Norge/Vänernbanan
AB Volvo	Good	Good	Not affected	Not affected
Eka Chemicals	Acceptable	NA*	Not affected	Improved
SAAB	Bad	Bad	Greatly improved	Greatly improved
SCA, Lilla Edet	Bad	NA*	Improved	Improved
SKF	Good	Good	Not affected	Not affected
Volvo Aero	Bad	Bad	Greatly improved	Greatly improved
Volvo Car Corporation	Good	Good	Not affected	Not affected

* = Not applicable since there are no train stations between Göteborg and Trollhättan

Table 4.20

How would you describe the company's recruitment situation and could it be improved by an infrastructure investment in R45 and Norge/Vänernbanan?

Company	R45 today	Norge/Vänernbanan today	Investment in R45	Investment in Norge/Vänernbanan
AB Volvo	Good	Good	Not affected	Not affected
Eka Chemicals	Acceptable	NA*	Improved	Improved
SAAB	Bad	Bad	Greatly improved	Greatly improved
SCA, Lilla Edet	Acceptable	NA*	Improved	Improved
SKF	Good	Good	Not affected	Not affected
Volvo Aero	Bad	Bad	Greatly improved	Greatly improved
Volvo Car Corporation	Good	Good	Not affected	Not affected

* = Not applicable since the company does not use it

Table 4.21

Would investments in R45 and Norge/Vänernbanan affect the company's strategies regarding potential new investments and future developments?

Company	Investment in R45	Investment in Norge/Vänernbanan
AB Volvo	No	No
Eka Chemicals	No	No
SAAB	To some extent	No
SCA, Lilla Edet	No	No
SKF	No	No
Volvo Aero	No	No
Volvo Car Corporation	No	No

Table 4.22

Would the company's competitive situation be affected by investments in R45 and Norge/Vänernbanan?

Company	Investment in R45	Investment in Norge/Vänernbanan
AB Volvo	No	No
Eka Chemicals	Possibly	Possibly
SAAB	Yes	Yes
SCA, Lilla Edet	No	No
SKF	No	No
Volvo Aero	Yes	Yes
Volvo Car Corporation	No	No

Table 4.23

What is the company's current and future approximate freight volume per day in terms of the number of train sets and trucks?

Company	R45 today	Norge/Vänernbanan today	Investment in R45	Investment in Norge/Vänernbanan
AB Volvo	15 trucks*	NA**	Same as today	Same as today
Eka Chemicals	25 trucks	1 train set ***	Same as today	Same as today
SAAB	200 trucks	Seldomly used	Same as today	Same as today
SCA, Lilla Edet	100 trucks	2 train sets***	Same as today	Same as today
SKF	NA**	NA**	Same as today	Same as today
Volvo Aero	11 trucks	NA**	Same as today	Same as today
Volvo Car Corporation	15 trucks*	NA**	Same as today	Same as today

* = In total, AB Volvo and Volvo Car Corporation have a freight volume of 30 trucks per day on R45. Therefore, we divided the 30 trucks equally between the two companies.

** = Not applicable since the company does not use it

*** = One set equals 20 train wagons.

Table 4.24

How large are the company's freight volumes on R45 and Norge/Vänernbanan in comparison to other roads and railways?

Company	R45 today	Norge/Vänernbanan today	Investment in R45	Investment in Norge/Vänernbanan
AB Volvo	Very small	NA*	Same as today	Same as today
Eka Chemicals	Rather large	Large	Same as today	Same as today
SAAB	Large	Small	Same as today	Same as today
SCA, Lilla Edet	Large	Large	Same as today	Same as today
SKF	Very small	NA*	Same as today	Same as today
Volvo Aero	Large	Small	Possibly increased	Same as today
Volvo Car Corporation	Very small	NA*	Same as today	Same as today

* = Not applicable since the company does not use it

Table 4.25

Does the company experience any problems when or if it carries freight on R45 or Norge/Vänernbanan?

Company	R45 today	Norge/Vänernbanan today
AB Volvo	No	NA*
Eka Chemicals	Yes	Yes
SAAB	Yes	Yes
SCA, Lilla Edet	Yes	No
SKF	No	NA*
Volvo Aero	Yes	NA*
Volvo Car Corporation	No	NA*

* = Not applicable since the company does not use it

Table 4.26

Would investments in R45 and Norge/Vänernbanan solve these possible problems?

Company	Investment in R45	Investment in Norge/Vänernbanan
AB Volvo	NA*	NA*
Eka Chemicals	Yes	Partly
SAAB	Yes	No
SCA, Lilla Edet	Yes	NA
SKF	No	NA*
Volvo Aero	Yes	NA*
Volvo Car Corporation	NA*	NA*

* = Not applicable since the company does not use it

Table 4.27

Would the company consider changing its current choice of transportation mode when carrying freight if investments in R45 and Norge/Vänernbanan were undertaken?

Company	Investment in R45	Investment in Norge/Vänernbanan
AB Volvo	No	No
Eka Chemicals	No	No
SAAB	No	No
SCA, Lilla Edet	No	No
SKF	No	No
Volvo Aero	No	No
Volvo Car Corporation	No	No

Table 4.28

5 EVOLUTION OF DEMAND FOR TRANSPORTATION BETWEEN GÖTEBORG AND TROLLHÄTTAN

The evolution of the demand for transportation, the effect on demand of an increased capacity, and how the demand may affect the payoff of an infrastructure investment along R45 and Norge/Vänernbanan can be described in several ways. The current demand forecasting model that is used by SIKA, Vägverket, and Banverket is a model called Sampers. This model is interesting to us in the sense that one of its main weaknesses is that the calculated cross elasticities are suspected to be too low⁵⁵. To understand why weaknesses, such as the one mentioned, occur, we consider it important to explain how Sampers is constructed and which types of demand effects the model can capture. In our analysis, we have described the evolution of the demand in a different way since we have used the microeconomic approach instead of the traditional four-stage transport approach, which Sampers is based on. That is, the microeconomic approach enabled us to calculate the elasticities and cross elasticities between different modes in a different way than they are calculated in Sampers. Furthermore, in contrast to the methodology in Sampers, we have performed company interviews and we have explained how one can use scenario analysis within the field of transportation.

5.1 Current Demand Forecasting Model: Sampers

Sampers has been used since 1999 and it consists of one international model, one national model, and five different regional models. According to Fröidh, Sampers can evaluate the following areas⁵⁶:

- Demand effects of new infrastructure and new transport supply
- Demand effects of changing factors, such as socio-economic, demographic, or commercial changes
- Traffic safety effects
- Environmental effects
- Energy consumption effects

⁵⁵ Helena Braun (071103)

⁵⁶ Fröidh (2003)

- Accessibility effects
- Regional effects

When calculating the demand in Sampers, there are four different steps that need to be taken. The four steps are trip generation, trip distribution, modal split, and route assignment by mode⁵⁷. In the first stage, the total number of trips originated in each zone is calculated. In the second stage, one observes the destinations for the trips calculated in the first stage and in the third stage the choice of travel mode is registered. In the fourth stage, one assesses the routes for each trip⁵⁸. When calculating the route, one is using a route choice model called EMME/2. In EMME/2, the different routes are decided by using networks of nodes and links where all relevant roads, bus lines, railway lines etc. are included⁵⁹. The main reason for using a four-stage model is to find a logical and easy way to perform the needed calculations⁶⁰.

The calculation of the parameters in Sampers is based on a number of surveys, and hence the data used is disaggregated data. Each individual's travel behavior is mapped as well as the different alternatives that the individual had, such as other modes that the individual could have chosen. Thereafter, a statistical analysis is performed where the mentioned parameters are estimated⁶¹. The most important survey used in Sampers is Riks-RVU 94-98 (the National Survey of Travel Behavior). Riks-RVU contains 30,000 interviews in total. The survey contains a one-day diary, where one finds out all the trips taken by each individual during that day. Additionally, the survey investigates any trips longer than 100 km taken during the last month and also any trips longer than 300 km taken in the second to the last month⁶².

5.1.1 The Nested Logit Model and Potential Weaknesses

A weakness with using a nested logit model, which is the model used in Sampers when analyzing the survey results, is the fact that the nested logit model is estimated based on a state of equilibrium, which results in a model

⁵⁷ Fröidh (2003)

⁵⁸ Rosenlind, Lind, & Troche (2001)

⁵⁹ Fröidh (2003)

⁶⁰ Rosenlind, Lind, & Troche (2001)

⁶¹ SIK A Rapport 2002:4

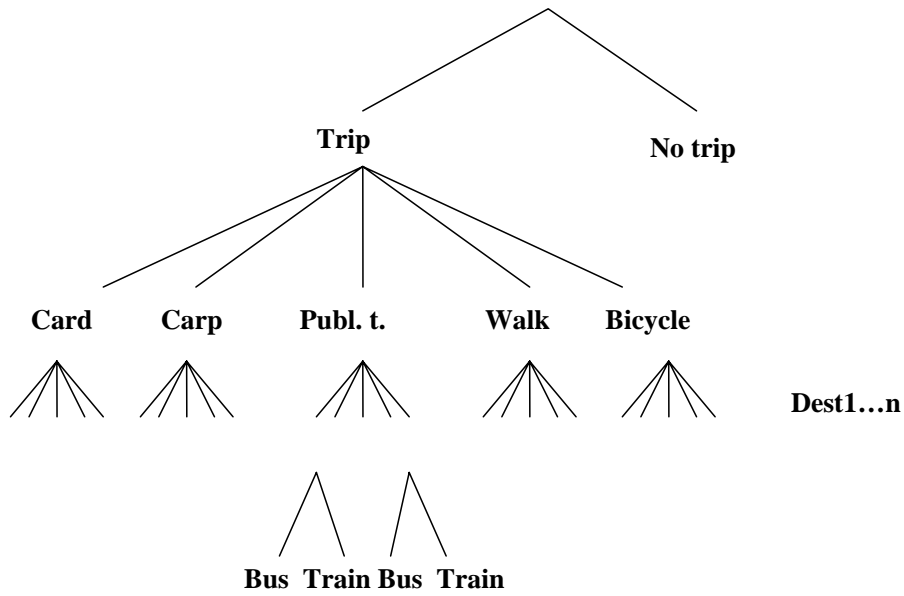
⁶² Helena Braun (071103)

that will not be able to calculate the effects of dynamic changes in an accurate way. Dynamic changes are represented by major changes or continuous changes in the population's travel habits or behavior. Typical effects resulting from dynamic changes are changes in the percentage of the population that owns a car, or changes in the housing or labor markets. These types of dynamic effects cannot be discovered in a satisfying way in a model that is based on a state of equilibrium. Instead, the results may forego hidden demand or long-term changes in travel behavior⁶³.

According to Helena Braun at SIKa, who is involved with the development of Sampers, it has recently been discovered that the model does not properly capture the transfer effects between different transportation modes. When evaluating two interdependent infrastructure investments, one must carefully consider possible transfer effects, such as how car commuters' behavior may change if an investment in a railway is undertaken. Furthermore, one must analyze which factors, such as traveling time, comfort, and mode frequency, affect different types of commuters and to what extent these commuters are affected. If one cannot measure and describe the demand for transportation appropriately and catch possible transfer effects between different modes, it is very difficult to determine the true effect that the demand for transportation has on the payoff from an infrastructure investment.

The fact that the model does not capture these transfer effects in an appropriate way may be explained by how the model describes the choice between train and bus or it may be explained by how the model is implemented and used. In Sampers, the choice between train and bus is made at the lowest level in the current structure, which could affect the estimation of the cross elasticities and thereby lead to an underestimation of possible transfer effects. Firstly, the individual makes a choice whether to go with public transportation or not, and secondly the individual chooses train or bus. The figure below depicts how Sampers currently is constructed for trips to work:

⁶³ Fröidh (2003)



Source: www.sika-institute.se (201103)
 Figure 5.1

The models that existed before Sampers was implemented tended to be too sensitive when train services and bus services were offered parallel to each other. Therefore, one made the decision to change the structure and move the individual's choice between train and bus to the lowest level as is the case in Sampers. However, the results from the new methodology in Sampers has shown that the model is too insensitive to the choice between train and bus, which is seen as a more serious problem than the previous problem with too high sensitivity when two different services are parallel to each other. Therefore, SIKa believes that it would be more appropriate to change Sampers so that the choice between train and bus would be made at a higher level, as was the case in the previous models⁶⁴.

In 2002, SIKa did an investigation of how well the different models in Sampers work and they also investigated different ways that the current models can be improved in order to better reflect the demands and characteristics of different population groups. One of the most important conclusions was that the models used do not sufficiently capture how the travel behavior changes within different groups when a major change in, for example, supply occurs.

⁶⁴ www.sika-institute.se (251003)

According to SIKÅ, the reason behind this weakness was that the large differences in characteristics between the different groups are not represented in the models. The results also showed that the most important characteristic affecting the groups was the income factor. Furthermore, the investigation showed that both gender and age also affect travel behavior. The number of available surveys is, however, too small to make the age factor statistically significant. Regarding the updating of the databases, SIKÅ found that the different groups tend to change their characteristics rather slowly. Therefore, the frequency of the updating of the data in Sampers does not need to be very high⁶⁵.

In general, one can say that Sampers is well documented but that its current structure needs to be improved to better reflect how individuals tend to make the choice between train and bus. That is, the model needs to better reflect possible transfer effects between different modes. The internal validation of Sampers shows that it is able to reproduce the journeys in the national surveys, which is very important since the parameters estimated in the model are based on these results. It is, however, the total volume of traffic that shows accurate and satisfying results⁶⁶. Accordingly, the simplification of the data collected in the surveys and the simplifications that have been made when building the models do not affect the overall result in a major way⁶⁷. However, at the disaggregated levels there are large differences. By disaggregated levels, one means the analysis of factors such as trips by different socioeconomic groups, different modes, or different trip purposes.

5.2 Elasticities obtained through Multinomial Logit Model

The effect of underestimated cross elasticities, which is the case in Sampers, is that possible transfer effects between different modes are not evaluated to the extent that they should be when deciding upon which infrastructure investments to make. Therefore, we found it interesting to focus on the concepts of elasticities and cross elasticities when describing the demand along R45 and Norge/Vänernbanan. The basic concepts of elasticities and cross

⁶⁵ SIKÅ Rapport 2002:4

⁶⁶ Fröidh (2003)

⁶⁷ SIKÅ Rapport 2002:4

elasticities are explained in Appendix VIII. Through elasticities and cross elasticities one can measure different probabilities to choose a specific mode with respect to certain factors. In our thesis, these factors are changes in traveling time for car, bus, and train, and changes in the mode frequency for bus and train. However, our calculation and evaluation of elasticities and cross elasticities differ from Sampers' treatment of these concepts. As mentioned before, we used the microeconomic approach of travel choice whereas Sampers is based on the traditional four-stage transport approach. Furthermore, Sampers includes a much larger sample than our survey since Sampers aims to generalize its findings into larger contexts. Additionally, Sampers calculates a larger number of elasticities and cross elasticities than we do since it includes more factors than just the traveling time and the mode frequency.

5.3 Effects on Demand of Changes in Traveling Time

As mentioned previously, we have calculated the elasticities and cross elasticities among car, bus, and train commuters with respect to traveling time and mode frequency. In chapter four, we concluded that the elasticity among car commuters is larger than the elasticities among bus and train commuters when analyzing the effect of a change in the traveling time for each specific mode. Furthermore, the largest cross elasticities when analyzing the effect of a change in the traveling time are obtained with respect to the traveling time for train. The table below presents the elasticities and the cross elasticities for each type of commuter with respect to a change in the traveling time for each specific mode:

Choice	Elasticity	Cross elasticities		
		Car	Bus	Train
Car	0,501	NA	-0,171	-0,171
Bus	0,258	-0,191	NA	-0,191
Train	0,342	-0,556	-0,556	NA

Table 5.1

The relationships between the elasticities and cross elasticities among the different types of commuters bring about an interesting discussion when one evaluates two interdependent investment projects. The elasticity among car commuters is 0,501, which implies that an increase of 1% in the reduction of

the traveling time by car increases the probability among the car commuters to choose car by approximately 0,5%. The cross elasticities among bus and train commuters with respect to a change in the traveling time by car are -0,171. These cross elasticities mean that if the reduction in the traveling time by car increases by 1%, the probabilities of choosing either bus or train decrease by approximately 0,2% among bus and train commuters.

The interpretation of the remaining elasticities and cross elasticities presented in table 5.1 can be found in Appendix IX.

5.3.1 Elasticity among Car Commuters

As mentioned above, the elasticity among car commuters is the highest among the three modes. That is, the probability for choosing car increases the most with respect to a reduction in its traveling time. This behavior among commuters could depend on several different factors. When looking at the results from our discrete choice experiments concerning traveling time, we can conclude that to an extent of 78% car commuters chose car as their mode alternative. Furthermore, 82% of Car 1 commuters and 56% of Car 2 commuters said that they chose car because it was their fastest alternative. Additionally, 12% of Car 1 commuters and 22% of Car 2 commuters said that they chose car because it was their most comfortable alternative. That is, the car alternative seems to satisfy the needs and requirements for speed and comfort among car commuters. Furthermore, only 6% of Car 1 commuters and Car 2 commuters said that they chose car because there were no suitable bus or train connections to their work. Additionally, none of Car 1 commuters and only 4% of Car 2 commuters stated that they chose car because there were no public transportation alternatives available to reach their work. Only 12% of Car 2 commuters answered that they chose car because it was required in their work. We can, therefore, conclude that a very small number of car commuters commute by car because they are not able to use the public transportation system and that the majority of the car commuters seem to choose car as their first choice.

Oskar Fröidh has investigated the market effects of regional high-speed trains on Svealandsbanan in the Mälaren Valley⁶⁸. In his study, he investigated the main reason car commuters chose to go by car. According to his results, the three main reasons for choosing car were that it was simpler, faster, or more comfortable. In our questionnaire, we did not include a variable called simpler, but except for that, our results are the same as Fröidh's results. In spite of the fact that Fröidh used a larger sample than we did, we received almost the same results as Fröidh, which strengthens the reliability of our study.

Cross Elasticity among Car Commuters with Respect to Traveling Time for Bus

The cross elasticity among car commuters with respect to the change in the traveling time for bus is low. Our discrete choice analysis concerning traveling time concludes that none of the car commuters chose bus in any of the questions. One reason why car commuters do not seem willing to change from car to bus is that they seem very satisfied with their current mode choice. As mentioned above, they consider the car alternative as a fast and comfortable choice. Comfort seems to be an important factor to car commuters since comfort was ranked among the top three most important factors if they were to travel by bus. Other factors that seem important to car commuters are accessibility, speed, and cost. In comparison to speed and cost, comfort and accessibility are more difficult to compare and value between different modes. Bus and car commuters could experience comfort differently. Bus commuters, for example, may think of comfort as being able to sleep or read while going to work. Car commuters, on the other hand, may include flexibility and independence in the concept of comfort. Accessibility is also difficult to compare between different modes. For example, car commuters usually start their trip to work from their houses where their cars are parked whereas bus commuters cannot control where the closest bus station is. Therefore, these two types of commuters may have different opinions about what is accessible and what is not. In summary, one can say that even if the traveling time for bus is reduced, very small transfer effects from car to bus can be expected since the bus alternative does not seem to fulfill the car commuters' needs for different factors, such as comfort and accessibility.

⁶⁸ Fröidh (2003)

Cross Elasticity among Car Commuters with Respect to Traveling Time for Train

The cross elasticity among car commuters with respect to the change in the traveling time for train is larger than the cross elasticity among car commuters with respect to the change in the traveling time for bus. That is, if car commuters were to change transportation mode, they would rather choose train than bus. Our discrete choice analysis showed that car commuters chose train to an extent of 22% in our different alternatives. One reason car commuters would rather travel by train than by bus could be that train is more similar to car in the sense that there are fewer stops if one is traveling by train than by bus. If car commuters were to travel by train, they rank accessibility, speed, comfort, and cost as the most important factors. These factors are the same factors that were highly ranked if they were to travel by bus. Accordingly, since car commuters are more willing to change to train than to bus, we believe that train to a larger extent is able to fulfill car commuters' needs for these factors than bus. An interesting observation that could be made is that since Limdep is only able to produce symmetric cross elasticities, the cross elasticities from car to train and from bus to train are equal even though car commuters chose train to the extent of 22% in our discrete choice experiments whereas bus commuters chose train to the extent of 52%. Thus, the cross elasticity from car to train seems a bit too high.

5.3.2 Elasticity among Bus Commuters

The elasticity among bus commuters is lower than the elasticities among car and train commuters. Accordingly, the probability among bus commuters of choosing bus with respect to a reduction in its traveling time increases by less than the probabilities among car and train commuters of choosing car or train with respect to a reduction in their traveling times. Looking at the results from our discrete choice experiments, we can conclude that bus commuters seem dissatisfied with their current mode choice. These results show that bus commuters to a larger extent than train and car commuters chose other modes than their current mode in the different alternatives. More specifically, bus commuters chose bus to the extent of 31%, train to the extent of 52%, and car to the extent of 17% in the different alternatives. Another interesting fact to consider is that a large part of the bus commuters did not seem to choose bus

because they like its characteristics, but rather because they were not able to choose car or train. This may explain why the increase in the probability for choosing bus is lower than the increase in the probabilities for choosing car or train when the traveling time for each mode is reduced.

Cross Elasticity among Bus Commuters with Respect to Traveling Time for Car

As mentioned above, many bus commuters seem dissatisfied with their current mode choice. Therefore, it could be expected that the cross elasticity among bus commuters when the traveling time for car decreases should be large. However, this is not the case. Our experiments show that bus commuters only chose car to an extent of 17% in the different alternatives. There are mainly two factors that explain this behavior among bus commuters. Firstly, 100% of all car commuters and 88% of train commuters have a driving license, whereas only 66% of bus commuters have a driving license. Secondly, a considerably lower percentage of bus commuters have car access compared to train commuters and both types of car commuters. From these factors, it can be concluded that a smaller share of bus commuters is able to choose car as their transportation mode than train and car commuters. Another factor that could explain the low cross elasticity between bus and car is that car is a more expensive alternative than bus; and bus commuters are more concerned about cost (in monetary terms) than car commuters.

Cross Elasticity among Bus Commuters with Respect to Traveling Time for Train

The cross elasticity among bus commuters with respect to a change in the traveling time for train is larger than the cross elasticity among bus commuters with respect to a change in the traveling time for car. This pattern seems reasonable since many bus commuters do not have a driving license or car access, which is required for car but not for train. However, current bus commuters face an obstacle, which makes it impossible to realize these possible transfer effects. The bus commuters in our sample only travel other distances than Göteborg-Trollhättan and therefore they need a train station between Göteborg and Trollhättan in order to actually consider train commuting as an alternative. A possible reason why bus commuters want to change to train from bus if the traveling time for train improves is that bus commuters rank speed as number one if they were to travel by train. Bus

commuters rank comfort as a rather unimportant factor if they were to travel by train, which implies that the train services do not need to provide a high level of comfort in order to attract bus commuters.

5.3.3 Elasticity among Train Commuters

In comparison to bus commuters, train commuters seem to be very satisfied with their current transportation mode. According to the results from our discrete choice experiments, train commuters chose train to the extent of 85% in the different alternatives. The elasticity among train commuters is the second highest elasticity after the elasticity among car commuters, which could be caused by several different factors. Among train commuters, 88% have a driving license and 72% have car access. These numbers imply that train commuters chose train even though a large part of the commuters could have chosen car, which also seems to be perceived as an attractive mode. Another factor that could affect the elasticity among the train commuters is that the train commuters ranked speed as the most important factor when traveling by train. Furthermore, the second most common reason for choosing train is that it is regarded as the fastest alternative. Accordingly, it seems logical to expect that train would be regarded as an even more attractive mode if the traveling time was reduced.

Cross Elasticity among Train Commuters with Respect to Traveling Time for Car

The cross elasticity among train commuters with respect to a change in the traveling time for car is rather small. This relationship seems natural since train commuters are very satisfied with their current choice. As discussed above, most train commuters chose train even though they had a driving license and car access. Our results show that train commuters to the extent of 85% chose train in our different alternatives. Compared to the number of choices of bus by bus commuters and car by car commuters, train commuters chose their current mode to the largest extent. This behavior further explains why train commuters may not change to car if the traveling time for car is reduced. An additional factor that could explain why train commuters do not tend to choose car could be that they perceive the car alternative as being too expensive. Train commuters seem to be concerned about the cost (in monetary terms) of commuting since they rank cost among the top three most important factors

when traveling by train and if they were to travel by bus. Furthermore, 22% of the train commuters in our sample said that they chose train because it was their cheapest alternative.

Cross Elasticity among Train Commuters with Respect to Traveling Time for Bus

The cross elasticity among train commuters with respect to a change in the traveling time for bus is also rather small. This relationship mainly depends on the same factors that explain why train commuters are not particularly willing to change to car if the traveling time is improved. That is, train commuters are very satisfied with their current choice. Currently, a trip between Göteborg and Trollhättan takes 15 more minutes by bus than by train. The largest improvement that we analyzed when measuring the effects of a change in the traveling time for bus was 20 minutes. This improvement results in a bus trip between Göteborg and Trollhättan that is five minutes shorter than a train trip. In conclusion, one can say that train commuters who value time extremely highly would perhaps choose bus. However, it should be noted that 44% of the train commuters we interviewed chose train because it was their most comfortable alternative. Accordingly, it seems reasonable that the probability of choosing bus instead of train is rather small. The cross elasticity among train commuters with respect to a change in the traveling time by bus is larger than the cross elasticity among train commuters with respect to a change in the traveling time by car. This seems strange since train commuters chose car to an extent of 11% while they only chose bus to the extent of 3% in our different alternatives. One possible explanation could be how the Limdep program is constructed. The Limdep program only produces symmetric cross elasticities, which may not always catch reality.

5.4 Effects on Demand of Changes in Mode Frequency

The elasticities and cross elasticities with respect to a change in the mode frequency are higher than the elasticities and cross elasticities with respect to a change in the traveling time. Accordingly, one can conclude that mode frequency has a larger effect on the commuters' traveling behavior than traveling time. The table below shows the elasticities and cross elasticities for each type of commuter with respect to a change in the mode frequency for each specific mode:

Choice	Elasticity	Cross elasticities		
		Car	Bus	Train
Bus	0,638	-0,517	NA	-0,517
Train	0,445	-0,710	-0,710	NA

Table 5.2

The elasticities and cross elasticities presented in table 5.2 are interpreted in the same way as the elasticities and cross elasticities in table 5.1. See Appendix IX for a detailed interpretation.

5.4.1 Elasticity among Bus Commuters

The increase in the probability for choosing bus among bus commuters was higher if the number of departures per hour increased than if the traveling time for bus was reduced. This result is strengthened by the fact that bus commuters, to a larger extent, chose bus in our discrete choice experiments if the mode frequency changed than if the traveling time changed. More specifically, bus commuters chose bus to the extent of 42% if the mode frequency was improved whereas bus commuters only chose bus to the extent of 31% if the traveling time for bus was improved. These results indicate that the bus commuters want the current frequency to be increased. If considering the ranking of speed and mode frequency when traveling by bus, bus commuters rank these two factors among the top three. Speed is ranked higher than mode frequency, but still mode frequency has a higher effect on bus commuters' choice of mode than speed. One reason why mode frequency seems to affect bus commuters more than a reduced traveling time does is the fact that only 60% of the bus commuters are able to influence their working hours. Accordingly, if the mode frequency for bus increases, bus commuters may to a larger extent be able to match their arrival and departure with their working hours. This argument is to some extent also valid for reduced traveling times, but we believe that an improved mode frequency would make it easier for employees to match their working hours than would a shortened traveling time. Another interesting fact is that the elasticity among bus commuters is larger than the elasticity among train commuters, which was not the case when studying the effects of changes in traveling time. Accordingly, this result may imply that a higher mode frequency for bus could improve the satisfaction among bus commuters significantly and perhaps make them less willing to change to other modes.

Cross Elasticity among Bus Commuters with Respect to Mode Frequency for Train

Evidently, the cross elasticity among bus commuters with respect to a change in the mode frequency for train is rather large. Our discrete choice experiment showed that bus commuters chose train to the extent of 43% in the different alternatives. Like the discrete choice experiments focusing on traveling time, bus commuters chose train to a larger extent than bus. However, more bus commuters chose bus to a larger extent if the mode frequency changed than if the traveling time changed. One should be aware of the fact that the transfer effects between bus and train can only be realized if a train station is built between Göteborg and Trollhättan since none of the bus commuters in our sample travels from Göteborg to Trollhättan, or vice versa.

5.4.2 Elasticity among Train Commuters

Changes in mode frequency also seem to affect train commuters more than changes in the traveling time. However, the difference between the elasticities among the train commuters with respect to a change in traveling time and mode frequency is quite small. The conclusion that the elasticity among train commuters is larger with respect to the mode frequency than with respect to the traveling time for train is further enhanced by the fact that train commuters chose train to the extent of 90% in the different alternatives when focusing on mode frequency compared to 85% when focusing on traveling time.

Cross Elasticity among Train Commuters with Respect to Mode Frequency for Bus

If the mode frequency for bus changed, the transfer effects from train to bus would be larger than if the traveling time for bus was reduced. In accordance with our elasticity results, our discrete choice experiments showed that train commuters to a larger extent chose bus if the mode frequency for bus changed than if the traveling time changed.

Cross Elasticity among Car Commuters with Respect to Mode Frequency for Bus and Train

Regarding the cross elasticity among car commuters with respect to mode frequency for bus and train, it can be said that car commuters seem more willing to travel by train or bus if the mode frequency changed rather than if the

traveling time changed. This relationship may be explained by the fact that car commuters may experience an increased mode frequency as an increased accessibility, which is highly ranked by car commuters if they were to travel by train or bus. That is, the public transportation alternatives can better fulfill the car commuters' needs for accessibility if the mode frequency improves. If mode frequency changes, car commuters tend to choose train more often than they choose bus. More specifically, when the mode frequency changed, car commuters chose train to an extent of 32% while they chose bus to an extent of 10% in our different alternatives. To explain this behavior, we believe that the car commuters' requirements for comfort should be considered.

5.5 Company Interviews

The general recommendation when estimating the demand for infrastructure investments is that one should be very careful when including a company's opinion about a certain infrastructure investment since it has been proven that companies' effects on the actual demand and payoff of the infrastructure investment tend to be very small⁶⁹. However, in areas where people are heavily dependent on certain companies, these effects may be significant. Trollhättan is seen as a very vulnerable city because it is dependent on a few large companies, notably SAAB and Volvo Aero⁷⁰. Therefore, we found it appropriate to include certain companies' opinions about the needs for infrastructure investments in the area.

It is difficult to draw any general conclusions about infrastructure investment decisions from our company interviews since the companies interviewed use R45 and Norge/Vänernbanan to different degrees, and hence their needs for investments in R45 and Norge/Vänernbanan differ.

5.5.1 Recruiting and Employee Commuting

R45 and Norge/Vänernbanan greatly affect the recruiting and the current employees' commuting situations at SAAB and Volvo Aero, both of which are situated in Trollhättan. The two companies' recruitment problems mainly occur when trying to recruit highly skilled employees, which the companies require.

⁶⁹ www.sika-institute.se (101103)

⁷⁰ Tomas Hultgren (201103)

The representative from SAAB who we interviewed gave us a good example of the difficulties in recruiting competent employees. Last year, SAAB was planning to hire 250 new employees. One thousand persons applied for the job, but of these, only 100 persons fulfilled the requirements for the job⁷¹.

Both Göteborg University and Chalmers University of Technology are situated in Göteborg, and therefore SAAB and Volvo Aero mainly have searched for highly skilled employees in this city. Both SAAB and Volvo Aero have large difficulties with retaining highly skilled employees living in Göteborg. According to the representatives from SAAB and Volvo Aero, this could be explained by the fact that people living in Göteborg are not particularly willing to move to Trollhättan and that the current commuting situation is wearing the employees down. On average, employees at Volvo Aero and SAAB commuting from Göteborg to Trollhättan deal with the commuting situation for approximately two years before they quit. This behavior affects the companies in a negative way because the money and time invested in these employees do not pay off in the long run.

To prevent this behavior among highly skilled employees, SAAB has transferred a large part of its departments requiring highly skilled employees to Pixbo outside Göteborg. Currently, about 500 people work in Pixbo. However, SAAB still needs engineers in Trollhättan. Even if the departments situated in Pixbo partly prevent SAAB's employees from quitting to the same extent as before, the company still faces some problems. These problems occur because the company is divided into two different sites, which make the employees split into different groups, affecting the company in a negative way. Furthermore, two sites require employees to travel between the two cities during working hours for important meetings. Accordingly, the partial solution to the current recruitment and commuting problems creates new problems.

In contrast to SAAB and Volvo Aero, SKF, AB Volvo, and Volvo Car Corporation are situated in Göteborg and hence these companies more easily attract highly skilled employees and thereby do not face the same recruitment

⁷¹ Anna Petre (300903)

problems or the same commuting problems as SAAB and Volvo Aero. SCA, which is situated in Lilla Edet, is faced with the same problems as SAAB and Volvo Aero but to a smaller extent. SCA experiences the same problems as SAAB and Volvo Aero when recruiting people to leading positions within the company. However, the larger part of SCA's employees are blue-collar workers and therefore SCA is able to search for many of its employees close by to where the company is situated. The recruitment process and the current commuting situation at Eka Chemicals AB are not seen as large problems since the company is situated in Bohus close to Göteborg.

In conclusion, one can say that an investment in R45 and/or in Norge/Vänernbanan would greatly improve the recruiting and employees' commuting situation at SAAB and Volvo Aero. Furthermore, SCA would also be positively affected but not to the same extent as SAAB and Volvo Aero. Eka Chemicals AB believes that the company would be positively affected by an investment in Norge/Vänernbanan if a train station was built in Bohus. SAAB and Volvo Aero even say that their competitive situation would be affected by an investment in R45 and/or Norge/Vänernbanan. Eka Chemicals AB says that the connection between improvements in R45 and/or Norge/Vänernbanan and other infrastructures is the deciding factor in whether Eka Chemical AB's competitive situation would be affected by an investment in R45 and/or Norge/Vänernbanan.

5.5.2 Freight Transports

R45 and Norge/Vänernbanan are not only used for commuters, but also for freight transports. However, SKF does not use R45 or Norge/Vänernbanan when transporting its goods. In general, SKF does not use railways when transporting its goods because SJ is not able to meet SKF's requirements for lead times. AB Volvo and Volvo Car Corporation use R45 to a very small extent when transporting their goods and do not transport any goods at all on Norge/Vänernbanan. Instead, they mainly use E20 to transport goods from plants in Skövde, Vara, Köping, and Eskilstuna. These companies mainly use trucks when transporting their goods since trucks usually are much easier and cheaper to use than train. AB Volvo also mentioned that freight transportation seems to have a very low priority within SJ and therefore AB Volvo sees the

train alternative as being rather risky since SJ may not deliver the company's goods on time.

Even if these companies only use R45 to a limited extent, they have a clear picture of which infrastructure investments in the western part of Sweden should be focused on. Furthermore, they believe that infrastructure will become even more important for companies and different regions in the future. That is, they can observe a logistic trend where there is a higher degree of specialization, which leads to fewer plants, and also to a higher degree of refined goods and products that will result in more sensitive goods and products in terms of how they are constructed.

Volvo Aero already has a high degree of refined goods and these goods require very secure transportation with few re-loadings. To achieve these secure transportations with few re-loadings, Volvo Aero has decided to ship their goods only on roads and not on any railways. R45 is the company's most important road when transporting its goods. The company ships many of its jet engines to the United States and therefore daily needs to transport some of its goods to Landvetter airport. During each day, about eleven transports go between Volvo Aero and Göteborg. The largest part of these transports is by truck. Like Volvo Aero, SAAB transports the majority of its goods between Göteborg and Trollhättan and mainly uses the road alternative. SAAB's reason for not using Norge/Vänernbanan is that it is much cheaper to transport its goods on R45 than by train. Currently, the daily number of trucks between Göteborg and SAAB is approximately 200.

Since both SAAB and Volvo Aero transport the majority of their goods on R45, it is relevant to get their views about current problems when using R45 for freight transports. The two main problems that they experience are accidents on the road and traffic congestion. Volvo Aero, for example, often has difficulties when trying to be on time for its different flights from Landvetter airport. However, both SAAB and Volvo Aero view these transportation problems as minor in comparison to the problems related to their recruiting and their employees' commuting situation. SCA and Eka Chemicals AB, which both are situated between Göteborg and Trollhättan, also experience similar

transportation problems as SAAB and Volvo Aero when transporting goods on R45. Additionally, these companies transport some of their goods on Norge/Vänernbanan. SCA is situated in Lilla Edet and Eka Chemicals AB in Bohus and hence SCA's transportation distance is longer than Eka Chemicals AB's transportation distance when transporting goods to Göteborg. Currently, one train set arrives at SCA and one train set departs from SCA during each day. Furthermore, approximately 65 trucks filled with goods reach SCA each day and approximately 35 trucks leave the company during each day. These freight volumes represent almost all of SCA's total freight since 95% of its freight is transported on R45 and Norge/Vänernbanan. Eka Chemicals AB uses both R45 and Norge/Vänernbanan when transporting its goods, but is not as heavily dependent on R45 as SAAB, Volvo Aero, and SCA. The daily total freight volume at Eka Chemicals AB is 25 trucks and one train set. Eka Chemicals AB only transports 30% of its goods on R45 while 40% is transported on E6. However, 30% of Eka Chemical AB's goods is transported on Norge/Vänernbanan. That is, 60% of the company's total goods is transported on R45 and Norge/Vänernbanan together.

The current low road and railway standards do not prevent the companies from producing and transporting the desired volume of goods. Therefore, the main reasons the companies favor an investment in R45 and/or Norge/Vänernbanan with respect to freight transportation are that the companies believe that these investments will reduce the number of accidents on the road and the traffic congestion. Accordingly, an investment in R45 and/or Norge/Vänernbanan will not increase the total freight volume at the different companies. That is, the companies will not cause any new freight traffic generation if the investments in R45 and/or Norge/Vänernbanan are undertaken.

5.5.3 Choice of Transportation Mode

None of the companies that we interviewed would consider changing their choice of transportation mode when transporting their goods if infrastructure investments in R45 and/or Norge/Vänernbanan would be undertaken. The reasons for not considering changing to another mode are different in the various companies. Volvo Aero is not able to change its transportation mode because of its highly refined, sensitive, and fragile goods. SAAB, on the other

hand, faces too large costs if it was to transport its goods by train. The choice of transportation mode at SCA and Eka Chemicals AB is dependent on whether their customers have train connections that go all the way to their industrial estate. SCA and Eka Chemicals AB always prefer the train alternative when possible. Accordingly, the choice of transportation at these companies is mainly dependent on what their customers demand and the customers' accessibility to a railway and not on investments in R45 and/or Norge/Vänernbanan. However, Eka Chemicals AB mentions that it would benefit from an investment if the single track at Norge/Vänernbanan were changed into two tracks. As mentioned above, SKF, AB Volvo, and Volvo Car Corporation mainly use other roads when transporting their goods and are not considering changing their current flow of goods if R45 and/or Norge/Vänernbanan were invested in.

5.5.4 Future Strategies

Only SAAB said that its future strategies regarding potential new investments and future developments could be affected by an investment in R45 and/or Norge/Vänernbanan. However, the other companies mentioned that their strategies possibly could be affected by an investment in R45 and/or Norge/Vänernbanan. That is, these companies could not point out these investments as a single factor that would affect their strategies, but that an improved infrastructure in the region would be considered together with a wide range of other factors. SAAB said that these investments to some extent would affect its strategies because the company is owned by General Motors (GM), which is a large multinational firm. SAAB is continuously subject to GM's evaluation about where it is most profitable to produce cars. That is, SAAB competes with other car companies owned by GM in car production. The competition with other car companies is extremely tough for SAAB since the Swedish government is not able to provide as favorable offers as, for example, some of the states in the U.S. with respect to plants and infrastructure.

5.6 Scenario Analysis

Scenario analysis can be used in the field of transportation to better estimate possible payoffs of different infrastructure investments and to better see effects of increased capacity on the demand. In scenario analysis the researcher

focuses on key uncertainties and certainties about the future, and constructs a number of plausible futures⁷².

The cross elasticities that we have calculated and the growth of traffic between Göteborg and Trollhättan are factors that we believe are important when deciding which infrastructure investments to undertake in the area. Cross elasticities are important because they measure transfer effects between different modes and the growth of traffic is important because it shows the development of the demand for transportation and hence it can measure the need for different investments in the area. However, these two factors involve some uncertainty and therefore the evaluation of investments in R45 and Norge/Vänernbanan could benefit from the application of a scenario analysis where these two uncertainties are focused on. When focusing on these two factors, a scenario analysis could be constructed in the following way:

Scenario Analysis	High Traffic Growth 3%	Most Likely Traffic Growth 1,8%	Low Traffic Growth 1%
High Transfer Effects	Scenario 1	Scenario 2	Scenario 3
Most Likely Transfer Effects	Scenario 4	Scenario 5	Scenario 6
Low Transfer Effects	Scenario 7	Scenario 8	Scenario 9

Table 5.3

In this scenario analysis, we created three different growth levels in traffic volume, where 3% was assumed to be high growth, where 1,8% was used as the most likely growth rate⁷³, and where 1% was assumed to be low growth. Concerning the transfer effects, we also created three different levels where the most likely transfer effects consist of the cross elasticities with respect to the traveling time used in our results, and where the high and low transfer effects are calculated as 50% higher or lower than the most likely transfer effects. We have chosen to analyze only one of these scenarios, Scenario 1, in more detail in order to describe how to proceed when using scenario analysis in the field of transportation. Scenario 1 is further presented below:

⁷² Goodwin & Wright (2001)

⁷³ Tomas Hultgren (201103). 1,8% has been used by Västsvenska Industri- och Handelskammaren in their calculations concerning infrastructure investments in the Western part of Sweden.

Scenario 1

Choice	Cross elasticities		
	Car	Bus	Train
Car	NA	-0,257	-0,257
Bus	-0,287	NA	-0,287
Train	-0,834	-0,834	NA

Growth rate = 3%

R45	Traffic Volume 2003	Traffic Volume 2013
Number of cars on R45/year⁷⁴		
Gbg Centrum-Marieholm	18,423,740	24,759,966
Marieholm-Angeredsbron	7,369,715	9,904,281
Angeredsbron-Älvängen	5,350,900	7,191,162
Älvängen-Södra Trollhättan	3,104,690	4,172,444
Södra Trollhättan-Båberg	2,759,765	3,708,893
Number of bus passengers/year⁷⁵	4,138,005	5,561,133
Number of trucks/year⁷⁶		
Gbg Centrum-Marieholm	1,180,775	1,586,863
Marieholm-Angeredsbron	472,310	634,745
Angeredsbron-Älvängen	531,440	714,211
Älvängen-Södra Trollhättan	424,860	570,976
Södra Trollhättan-Båberg	377,775	507,698
Norge/Vänernbanan	Traffic Volume 2003	Traffic Volume 2013
Number of train passengers/year⁷⁷	920,000	1,236,403
Number of freight trains/year⁷⁸	4,420	5,940

Figure 5.2

When calculating the traffic volumes in, for example, 10 years, the current yearly volume is used as a starting point and then the volume in 10 years is forecasted by using the given growth rate (see figure 5.2).

The traffic volume is used in order to study the development of traffic over time. Furthermore, the researcher can study to what extent the current capacity of the road and the railway can deal with an expanded traffic. Perhaps the researcher can observe that either the road or the railway, or both, need a higher

⁷⁴ Västsvenska Industri-och Handelskammaren Rapport nr 2003:5

⁷⁵ Jan Efraimsson (120603)

⁷⁶ Västsvenska Industri-och Handelskammaren Rapport nr 2003:5

⁷⁷ Anna-Karin Nilsson (251103)

⁷⁸ Peter Tholfson (100603)

capacity in order to handle the expanded traffic. By including different scenarios, the researcher can see how different growth rates affect the capacity of the road and of the railway. For example, the researcher must question if the section of R45 between Göteborg Centrum and Marieholm is able to handle a six million car increase in traffic in addition to the increases in bus traffic and trucks from 2003 to 2013. One of the main advantages with scenario analysis is that the researcher is better prepared for different types of futures. For example, the usage of scenario analysis could be very beneficial if either the passenger or the freight traffic to SAAB in Trollhättan increased significantly because, in that case, possible capacity shortages could be foreseen through the scenarios previously constructed.

Possible transfer effects are beneficial to use in a scenario analysis, because through these effects the researcher can see how the demand for various types of transportation modes are affected by different infrastructure investments. By combining cross elasticities and traffic volumes in a scenario analysis, the researcher can estimate the effect of these cross elasticities on the traffic volumes if an investment in the road or in the railway is undertaken. By using scenario analysis in this way, the researcher can determine how different investments, that is, an increased capacity, affect the demand for transportation and thereby see how the demand affects the payoff of different infrastructure investments.

When using scenario analysis in the case of R45 and Norge/Vänernbanan, the researcher could evaluate the effects on the demand for transportation through different investments. For example, the researcher could expect to see large transfer effects from bus to train if the traveling time for train was reduced. In order to realize transfer effects, investments in expensive train stations between Göteborg and Trollhättan must be made. Accordingly, the number of bus commuters who would change to train would need to compensate for the high investment cost involved when investing in train stations. However, to evaluate the payoff of this investment, the wide distribution of the bus commuters throughout the different municipalities must be considered as well as the fact that many current bus commuters do not start or end their trip in Ale

municipality⁷⁹. Accordingly, these bus commuters would probably not use train stations situated in Ale municipality.

The discussion above is a suggestion to how to apply scenario analysis in the field of transportation and on infrastructure investments. When constructing a complete scenario analysis, the researcher should consider the fact that the growth rate could vary between different transportation modes, such as between car and truck. Therefore, it could be necessary to include different growth rates for different modes of transportation. Furthermore, a much larger number of cross elasticities with respect to different factors, compared to those included in our example, should be included. If we were to apply scenario analysis on R45 and Norge/Vänernbanan, we would only be able to evaluate the effects on demand through investments that would either change the traveling time in car, train, or bus or through investments that would change the mode frequency for train and bus. That is, we would not be able to provide a complete scenario analysis for R45 and Norge/Vänernbanan. However, we can explain how scenario analysis could be applied in the field of transportation and the value of using such a tool.

5.7 Concluding Discussion

As mentioned before, Sampers tends to underestimate the cross elasticities between different modes. To underestimate the cross elasticities when evaluating two interdependent possible infrastructure investments may have a considerable effect on the payoff of the infrastructure investments. Therefore, we found it very interesting and important to focus on the elasticities and cross elasticities between different transportation modes. Since Trollhättan is very vulnerable in the sense that it is dependent on two large companies, Volvo Aero and SAAB, we decided to complement our survey with interviews with representatives at these companies in order to get a more complete picture of the demand for infrastructure investments in R45 and Norge/Vänernbanan. We did not evaluate enough factors to perform a relevant scenario analysis in the case of R45 and Norge/Vänernbanan. However, our intention when presenting how to apply a scenario analysis in the field of transportation was to stress the importance and the usefulness of this procedure when determining how an

⁷⁹ Jan Efraimsson (120603)

increased capacity can affect the demand for transportation, as well as how the demand can affect the payoff of an infrastructure investment.

6 INVESTMENT IN R45 & NORGE/VÄNERNBANAN

6.1 Underestimation of Costs in Infrastructure Investments

The investment costs involved when undertaking infrastructure investments are very high. For example, the planned investment in R45 is estimated to cost approximately SEK four billion. Therefore, it is of great importance that one is able to estimate these costs reasonably accurately. Researchers have different opinions regarding whether decision makers in the field of transportation are good at estimating these costs or not. Many researchers have different opinions because only a few comparative studies of actual and estimated costs exist within this field and often these studies are single-case studies. However, in 2002 Flyvbjerg et. al. published a paper where they presented an extensive study in this field⁸⁰. Their paper is based on a study of 258 transportation infrastructure projects undertaken between 1927 and 1998, located in twenty different countries in five continents. According to Flyvbjerg et. al., infrastructure investment costs tend to be underestimated in nine of ten cases and the underestimation phenomenon exists in all countries and all continents included in their sample. Furthermore, the actual costs involved in railway investments tend to be underestimated by an average of 45% and the actual costs involved in road investments tend to be underestimated by an average of 20%⁸¹.

Generally, there are four explanations of cost underestimation, which are technical, economic, psychological, and political explanations. Flyvbjerg et. al. believe that the two most important explanations are economic and political explanations. Economic explanations can be described in terms of economic self-interest or in terms of the public interest. Regarding economic self-interest, it is possible to point to projects where different stakeholders, such as construction firms or engineers, influence the forecasting process. Their influence may increase the likelihood of an investment being undertaken. Regarding public interest, project promoters and forecasters may intentionally forecast underestimated costs in order to influence public officials in charge of

⁸⁰ Flyvbjerg, Holm, & Buhl (2002)

⁸¹ IBID

the project so that these officials cut costs and thereby save the public's money. Political explanations can be seen as a connection between cost underestimation and interests and power. It can, therefore, be questioned whether forecasts are intentionally biased in order to lead to certain investments. Accordingly, the issue of lying has to be analyzed⁸².

6.2 Suggestions for Investments in R45 and in Norge/Vänernbanan

As mentioned in the introduction section, the NNK is used in Sweden when deciding on the priority of different infrastructure projects. The NNK tries to take into account all possible factors that may affect the cost and the social surplus of an investment, but factors such as economic self-interest and power can be difficult to judge. Furthermore, the final decision-making concerning infrastructure investments is not only based on the NNK, but is also based on political interests. For example, since Trollhättan is regarded as vulnerable due to its dependency on two large companies, one may suspect that the decisions for investments in R45 and in Norge/Vänernbanan are affected not only by the NNK, but also by political interests.

Our suggestions are not based on the NNK or on policy makers' view on investments in the area. Instead, we have formed an opinion about which investment or investments to undertake in the case of R45 and Norge/Vänernbanan through the knowledge gained from our survey and interviews. Accordingly, our recommendations are, in contrast to those of the NNK, solely based on the characteristics of the demand, possible transfer effects between different modes, and the effect demand has on the profitability of infrastructure investments between Göteborg and Trollhättan.

6.2.1 Current Investment Plan for R45 and Norge/Vänernbanan

Currently, the government is planning to expand R45 into a four-lane road with a railing in the middle and intersections below or above R45. Furthermore, the plan involves an expansion of Norge/Vänernbanan into double tracks and to offer high-speed train services⁸³. Furthermore, the government is planning to

⁸² Flyvbjerg, Holm, & Buhl (2002)

⁸³ www.vv.se (191103)

invest in six train stations in the municipality of Ale. High-speed train services will only be offered to passengers and will not include any freight transportation. This investment plan has been made using Sampers and the NNK. In our case, we have focused on elasticities and cross elasticities among different types of commuters and on interviews with different companies to evaluate the current investment plan and to decide upon an investment plan that we think is appropriate. According to our results, the current characteristics of the demand do not seem to indicate that an investment in double tracks in Norge/Vänernbanan is necessary. Furthermore, our results and comparisons to Svealandsbanan do not seem to favor an investment in six stations between Göteborg and Trollhättan. Additionally, the current demand seems to suggest that an expansion of R45 into a four-lane road with a railing in the middle and intersections below or above the road is advisable. The sections below will discuss the effects on car commuters, bus commuters, train commuters, and companies of possible investment plans in R45 and in Norge/Vänernbanan with respect to our results.

6.2.2 Investment in R45 and in Norge/Vänernbanan

Effect on Car Commuters

The tendency among car commuters to choose train in our discrete choice experiments should be carefully interpreted since rather many car commuters in our sample chose train, but still said that they would not be affected by a train station in Ale municipality. Accordingly, it seems as if these car commuters felt that the train alternative was more appropriate than the car alternative even if they were not planning on switching to train in reality since they said that a train station would not affect them. A rather large percentage of both Car 1 commuters (35%) and Car 2 commuters (49%) said that a train station in Ale municipality would positively affect them. However, a large part of these Car 2 commuters told us that the only reason why they would be positively affected by a train station was that they hoped that other commuters than themselves would choose train instead of car and hence that they would experience less traffic on R45. This behavior among car commuters may indicate that the true probability for choosing train is lower than our results show.

Our belief that the probability for choosing train should be lower than our results show and our belief that the probability among car commuters for choosing bus is very low indicate that large transfer effects from car to bus or train are not expected. Accordingly, it is not likely that car commuters would generate any new traffic on Norge/Vänernbanan even if investments were made in double tracks, high-speed trains, and stations between Göteborg and Trollhättan. Thus, the travel behavior among the car commuters would not affect the payoff of the planned investments in Norge/Vänernbanan in a positive way.

Our discrete choice questions show that car commuters seem satisfied with their current mode choice since the majority of the car commuters chose car with respect to changes in the traveling time and the mode frequency in our different alternatives. Another interesting aspect among the car commuters is that more than 10% of the car commuters chose car because they needed it in their work. That is, public transportation is not an alternative for these commuters. Additionally, the probability among the car commuters for choosing car if the traveling time by car is reduced is high in comparison with the probability among train and bus commuters for choosing train or bus with respect to a reduction in the traveling time by train or bus.

According to the discussion above, we can conclude that there is a large demand for a four-lane road among car commuters whereas car commuters do not seem to consider the train alternative as very attractive. Therefore, an increased capacity on Norge/Vänernbanan is not demanded by the car commuters.

Effect on Bus Commuters

As previously mentioned, bus commuters seem, in contrast to car commuters, dissatisfied with their current mode choice. The cross elasticities among bus commuters with respect to the traveling time for car and train and the mode frequency for train show that bus commuters seem more willing to change to train than to car. Furthermore, 88% of the bus commuters stated that they would be positively affected by a train station in Ale municipality. Therefore, one may expect large transfer effects between bus and train if the government

invests in stations, in double tracks, and in high-speed trains on Norge/Vänernbanan. However, the bus commuters in our survey do not commute between Göteborg and Trollhättan and therefore they will not benefit from double tracks or high-speed trains unless a train station or stations are built at suitable locations between Göteborg and Trollhättan. As mentioned in the section about scenario analysis, building train stations involves a large investment cost and it is questionable to what extent the possible transfer effects from bus to train will be able to cover these investments. Furthermore, to realize the possible transfer effects from bus to train, several train stations are required between Göteborg and Trollhättan. Otherwise, many bus commuters will find it too complicated to commute by train instead of by bus since a train station probably will be less accessible to them than a bus station.

The analysis of the behavior among the bus commuters in our sample showed that these commuters also could be positively affected by an expansion of R45 into four lanes. The results show that if the traveling time for bus decreased or if the bus frequency increased, the bus commuters would be more willing to choose bus. The largest effect was obtained when the bus frequency improved. We can therefore conclude that an increased road capacity on R45 would benefit the bus commuters, since it probably would be easier to increase the bus frequency without disturbing the flow of traffic if the road was expanded.

Effect on Train Commuters

Many of the train commuters chose train because it was their most comfortable or fastest alternative. Furthermore, the majority of the train commuters have a driving license and car access but they still decided to commute by train. An expansion of R45 into four lanes does not seem to affect train commuters as they would not substitute the train alternative with the car alternative. However, possible transfer effects from train to bus might be experienced if the mode frequency for bus increases, which would be facilitated by an expansion of R45.

Overall, train commuters seem to be satisfied with their current mode choice. However, 44% of the train commuters stated that they would be negatively affected by a train station in Ale municipality. Therefore, we can conclude that

if the government invests in six train stations between Göteborg and Trollhättan, there is a risk that some train commuters may choose the bus alternative instead. This risk should be carefully considered since a reduced number of train commuters between Göteborg and Trollhättan may affect the payoff of the investment in stations in a negative way. According to our results, the probability among the train commuters for choosing train increases by a reduced traveling time as well as by an increased train frequency. An increased train frequency affects the train commuters more strongly than a reduced traveling time. Since the train frequency affects the train commuters more than the traveling time, we find it reasonable to first of all investigate if the current capacity of the single track is able to manage a higher train frequency. Furthermore, it is reasonable to investigate whether high-speed trains could be used on the current track capacity. We believe that these improvements should be carefully considered before investing in double tracks.

Effect on Companies

As previously mentioned, the companies situated in Göteborg and interviewed in the thesis, that is, AB Volvo, Volvo Car Corporation, and SKF, will not be affected by any investments in R45 and Norge/Vänernbanan. Therefore, this section is only concerned with the effects of infrastructure investments on Volvo Aero, SAAB, SCA, and Eka Chemicals AB.

SAAB and Volvo Aero have difficulties in recruiting highly skilled employees and they are also very dissatisfied with their current employees' commuting situation. SCA faces similar but smaller recruiting and employee commuting problems. Concerning the freight transportation at these three companies, the companies say that the current capacity on R45 and Norge/Vänernbanan does not limit the companies' production capacity. Instead, the main problem related to freight transportation is that the companies demand safer transports. SAAB and Volvo Aero only transport their goods on R45 whereas SCA uses Norge/Vänernbanan to a small extent. Currently, these companies regard the recruiting and employee commuting problems as more serious than the freight transportation problems. Eka Chemicals AB does not face the same recruiting and employee commuting problems as SAAB, Volvo Aero, and SCA because

of its location near Göteborg. Like SCA, Eka Chemicals AB transports goods on both R45 and on Norge/Vänernbanan.

With respect to the problems discussed above and to the companies' current usage of R45, we can conclude that there is a large demand for an expansion of R45 into four lanes with a railing in the middle and intersections below or above the road. An expanded R45 would not generate more freight traffic from any of the companies discussed, but this investment would result in safer and cheaper freight transports. Furthermore, the commuting situation for current employees at these different companies would be greatly improved. Safer, cheaper, more comfortable, and a faster commute to these companies would probably also improve the recruitment and the retention of employees at these companies. We also believe that an improved bus frequency would be beneficial for the companies, especially those situated in the municipality of Ale or Lilla Edet.

Concerning Norge/Vänernbanan, we can conclude that the current and future freight volumes are not large enough to motivate an investment in Norge/Vänernbanan. However, an investment in Norge/Vänernbanan could solve some of the companies' recruiting and employee commuting problems. These problems could be solved by different types of investments in Norge/Vänernbanan. We do not believe that the number of people who commute to these companies is large enough to motivate an investment in double tracks. However, we suggest an investigation of the possibility of increasing the train frequency or investing in high-speed trains while using the same track capacity as today. Eka Chemicals AB favors an investment in a train station in Bohus, but we believe that the negative effect faced by the other companies through longer traveling times for their employees would be larger than the positive effect experienced by Eka Chemicals AB through a station. Therefore, we can conclude that the most beneficial investment plan for the companies in our sample would be to expand R45 into four lanes, to increase the bus frequency, and to improve the train frequency and/or to invest in high-speed trains on Norge/Vänernbanan.

6.3 Comparison between Norge/Vänernbanan and Svealandsbanan

When investigating different types of investments in Norge/Vänernbanan, such as train stations, there is a benefit in drawing parallels to Svealandsbanan. Svealandsbanan is a single-track line between Eskilstuna and Södertälje with a few passing points and a double track section of 10 km where passing without stopping can take place. From Södertälje, the passengers can easily reach Stockholm through the Grödinge line. Table 6.1 and table 6.2 present the population in the municipalities of Stockholm, Eskilstuna, Göteborg, and Trollhättan, and in the different municipalities between Stockholm and Eskilstuna and between Göteborg and Trollhättan:

Stockholm	Södertälje	Nykvarn	Strängnäs	Eskilstuna
758,148	79,613	8,204	30,015	90,089

Source: www.scb.se (191103)

Table 6.1

Göteborg	Ale	Lilla Edet	Trollhättan
474,921	25,835	13,010	52,937

Source: www.scb.se (191103)

Table 6.2

As can be seen in the tables above, the population in Stockholm municipality is almost twice as large as the population in Göteborg municipality. Furthermore, the population in Eskilstuna municipality is significantly larger than the population in Trollhättan municipality. In our case, it is especially interesting to compare the total population in the different municipalities between Stockholm and Eskilstuna with the total population in the different municipalities between Göteborg and Trollhättan. The total population between Göteborg and Trollhättan is approximately one third the total population between Stockholm and Eskilstuna. That is, Svealandsbanan may be utilized by many more people than Norge/Vänernbanan would be if there were train stations in the municipalities of Ale and Lilla Edet.

According to Bert Andersson, city architect in the municipality of Ale, the municipality does not have large growth potential, since the useful land is developed and since old company buildings, which are vacant but too

expensive to remove, largely occupy the remaining land. Additionally, both Ale municipality and Lilla Edet municipality have had negative patterns of migration, that is, a diminishing population, on average from year 1996 to year 2000⁸⁴.

When building Svealandsbanan, investments were made in five different train stations and these investments seem to be paying off because of the large number of people who are able to use these stations. However, investing in six stations between Göteborg and Trollhättan does not seem appropriate since the population between Göteborg and Trollhättan is considerably smaller than the population between Stockholm and Eskilstuna, and furthermore, since Ale municipality does not seem to face any large growth opportunities. An alternative solution for Norge/Vänernbanan could be to invest in fewer than six stations between Göteborg and Trollhättan in order to save some costs. However, fewer stations would lead to lower accessibility to train stations in the area. The importance of accessibility to a train station has been further developed by Fröidh. According to Fröidh, the distribution between car and public transportation trips is dependent on the distance between a train station and the household. Furthermore, Fröidh maintains that the stations should be situated where the concentration of people or working places is high and at locations where many people have a walking distance to the train station⁸⁵. These requirements are fulfilled by the current investment plan for Norge/Vänernbanan, but we believe that the number of people and the size of the companies in the area are not large enough to require six stations.

When studying the area from Göteborg to Trollhättan with respect to the number of companies and with respect to the size of the companies, the conclusion is that most companies as well as the largest companies tend to be situated in Göteborg and in Trollhättan. This pattern can also be seen in the case of Svealandsbanan where most companies are situated in Stockholm and in Eskilstuna. Svealandsbanan offers high-speed train services to provide an efficient transportation between Eskilstuna and Stockholm. The similar pattern in the distribution of companies in the area around Svealandsbanan and in the

⁸⁴ www.scb.se (201103)

⁸⁵ Fröidh (2003)

area around Norge/Vänernbanan further enhances the importance of being able to provide fast and efficient train services between Göteborg and Trollhättan.

6.4 Concluding Discussion

Infrastructure investments involve a certain degree of risk-taking since the true investment cost as well as the actual demand for a specific investment is difficult to foresee. Therefore, it is very important that policy makers choose measurement tools that are able to predict the investment cost and to describe the characteristics of the demand in an appropriate way. In our thesis, we have not estimated the investment costs related to R45 and Norge/Vänernbanan, but have only focused on describing different characteristics of the demand. In order to map the characteristics of the demand, we have mainly focused on the cross elasticities between different modes with respect to a change in the traveling time or in the mode frequency, and on interviews with seven companies situated in Göteborg municipality, Trollhättan municipality, Ale municipality, and in Lilla Edet municipality. By evaluating the cross elasticities between different modes when considering different investment alternatives, we were able to forecast possible transfer effects between car, bus, and train. We believe that the analysis of different transfer effects is valuable when considering two investments that may affect each other in various ways.

The following two tables summarize the effects of different investments in R45 and in Norge/Vänernbanan on car, bus, and train commuters and on companies situated in the municipalities of Göteborg, Trollhättan, Ale, and Lilla Edet.

Investments in R45	Investments in Norge/Vänernbanan	Effect on car commuters	Effect on bus commuters	Effect on train commuters
	Station in Ale municipality	No effect	Positive effect	Negative effect
Four-lane road, railing, intersections below or above road		Large positive effect	Small positive effect	Small positive effect; not particularly willing to change to car
Four-lane road, railing, intersections below or above road	Double tracks	Large positive effect through road investment, small positive effect through double tracks since not particularly willing to change to train	Small positive effect through road investment, no effect through double tracks	Small positive effect through road investment since not particularly willing to change to car, positive effect through double tracks
Four-lane road, railing, intersections below or above road	Double tracks/Station	Large positive effect through road investment, small positive effect through double tracks and station since not particularly willing to change to train	Small positive effect through road investment, large positive effect through double tracks and station since willing to change from bus to train*	Small positive effect through road investment since not particularly willing to change to car, positive effect through double tracks but negative effect through station
Four-lane road, railing, intersections below or above road/Increased bus frequency	Increased frequency or high-speed trains	Large positive effect through four-lane road, no effect through increased bus frequency, small positive effect through increased train frequency or high-speed trains since not particularly willing to change to train	Large positive effect through four-lane road and increased bus frequency, no effect through increased train frequency or high-speed trains	Small positive effect through a four-lane road, positive effect through increased bus frequency, positive effect through increased train frequency or high-speed trains

* Depending on where the train station is situated.

Table 6.3

Investments in R45	Investments in Norge/ Vänernbanan	Effect on companies in Trollhättan	Effect on companies in Göteborg	Effect on companies in Ale and in Lilla Edet
	Station in Ale municipality	Mainly negative effect	No effect	Positive effect
Four-lane road, railing, intersections below or above road		Large positive effect	No effect	Positive effect
Four-lane road, railing, intersections below or above road	Double tracks	Large positive effect through both road- and railway investment	No effect	Positive effect through both road- and railway investment
Four-lane road, railing, intersections below or above road	Double tracks/Station	Large positive effect through road investment, positive effect through double tracks but negative effect through station	No effect	Positive effect through both road- and railway investments
Four-lane road, railing, intersections below or above road/Increased bus frequency	Increased frequency or high-speed trains	Large positive effects through road investments and both types of railway investments	No effect	Positive effect through both road investments and through increased train frequency, no effect through high-speed trains

Table 6.4

Through our results and our analysis, we believe that the following investments should be taken:

- Expand R45 into four lanes with a railing in the middle and intersections below or above the road
- Increase the bus frequency
- Investigate whether one can increase the train frequency and/or invest in high-speed trains while keeping the current track capacity

An expansion of R45 into four lanes with a railing in the middle and intersections below or above the road would reduce the number of accidents on the road and traveling on R45 would become cheaper, faster, and more

comfortable for commuters as well as for freight transports. Accordingly, it would become more attractive to commute between Göteborg and Trollhättan than it presently is, which would benefit companies situated in Trollhättan.

By increasing the train frequency and/or investing in high-speed trains, while keeping the current single track, current train commuters would be satisfied. Furthermore, fast and efficient train services could be provided when commuting between Göteborg and Trollhättan where the most and the largest companies are situated and where the largest concentration of populations is located. Accordingly, these improvements in Norge/Vänernbanan would make it more attractive to commute between Göteborg and Trollhättan by train and hence these improvements would benefit the companies situated in Trollhättan.

Increased bus frequency would make commuting by bus more attractive to bus commuters, and it would also compensate bus commuters for no train stations between Göteborg and Trollhättan. Large transfer effects cannot be expected from car to train, and therefore the transfer effects from bus to train alone would have to compensate for the large investment costs in train stations. Furthermore, it is necessary to consider the fact that if train stations were built, some of the current train commuters may switch to another mode and thereby the train ticket sales would be reduced. For the train stations to pay off, the bus commuters would have to generate enough trips to cover the large investment costs in train stations as well as cover the costs involved with a reduced number of train commuters. With respect to the number of bus commuters who start or end their trip in Ale municipality, we do not believe that bus commuters are able to cover these costs.

Finally, it should be noted that the different investment suggestions discussed above would be undertaken by different administrations, such as the government, SJ, and Västtrafik.

7 CONCLUSION

This thesis had three main purposes. Firstly, our aim was to describe the evolution of the demand for transportation between Göteborg and Trollhättan in such a way that it could be used for decision-making. Secondly, we wanted to find arguments from a demand-oriented perspective for whether an investment in R45, in Norge/Vänernbanan, or in both the road and the railway, should be undertaken. Lastly, we wanted to find parallels between the investment in Svealandsbanan and the possible investment in Norge/Vänernbanan.

The main reason we decided to focus on these questions is that the current national models used in Sweden when deciding which infrastructure investments to take on (NNK) and when estimating the demand for passenger transportation (Sampers) have a number of weaknesses. NNK does not accurately distinguish between investments in independent projects and investments in interdependent projects. One of the weaknesses in Sampers is that the model produces cross elasticities, i.e. transfer effects, which seem to be underestimated. This weakness results in an estimate of the demand for transportation along R45 and Norge/Vänernbanan between Göteborg and Trollhättan that does not seem to reflect reality. Because of the weaknesses discussed, we found it interesting to search for new ways of estimating the demand for transportation between Göteborg and Trollhättan.

We used quantitative, qualitative, and comparative approaches in order to answer our three purposes and their related sub-purposes. In the quantitative approach, we performed a survey, in which we aimed to learn about commuters' travel behavior and preferences along R45 and Norge/Vänernbanan. This survey was based on discrete choice experiments, where the commuters were faced with a number of hypothetical situations. The results from these discrete choice experiments were used in the multinomial logit model, which in contrast to Sampers, is based on the microeconomic approach, to calculate elasticities and cross elasticities among car, train, and bus commuters with respect to changes in the traveling time and mode frequency. We can conclude that transfer effects may be realized if the

traveling time for car, train, or bus is reduced or if the mode frequency for train or bus is increased. We can also conclude that the probability of choosing a specific mode increases through a reduced traveling time and through an increased mode frequency. The quantitative approach also consisted of an explanation of how one can apply scenario analysis in the field of transportation. Through a scenario analysis, where one is including the traffic volumes and different transfer effects, one is able to estimate the effects on demand of an increased capacity and to determine what effects demand has on the payoff of different infrastructure investments.

The qualitative approach constituted of interviews with seven different companies situated in the municipalities of Göteborg, Trollhättan, Ale, and Lilla Edet. We conducted these interviews to determine these companies' use of R45 and Norge/Vänernbanan and their needs for investments in the road and the railway. The results from our interviews show that the companies that use R45 and Norge/Vänernbanan mainly demand an infrastructure investment between Göteborg and Trollhättan to improve the recruiting and commuting situations among their employees. Additionally, we can conclude that an infrastructure investment in the area would not generate any new freight transports by the companies interviewed.

The comparative approach was intended to find parallels between Svealandsbanan and Norge/Vänernbanan and to explore what one could learn from these parallels when evaluating different investment alternatives in Norge/Vänernbanan. The most important parallels that were found concern the similarities in and differences between the distribution of the population and the distribution of companies around Svealandsbanan and around Norge/Vänernbanan. These parallels can, for example, be used when evaluating the optimal number of train stations between Göteborg and Trollhättan.

From a demand-oriented perspective, we suggest to expand R45 into a four-lane road with a railing in the middle and intersections below or above the road, to increase the bus frequency, to investigate whether to increase the train frequency, and/or to introduce high-speed trains on Norge/Vänernbanan while keeping the current track capacity.

The essential findings of our thesis are that more focus should be placed on cross elasticities than Sampers does when evaluating the demand for transportation for interdependent projects. Additionally, an awareness that companies' needs and opinions may influence the payoff of an infrastructure investment in certain regions is required. By focusing more on cross elasticities and companies' needs in Sampers, a better estimate of the demand for transportation between Göteborg and Trollhättan is possible. Thereby, the accuracy of the calculations of NNK would improve. To better handle different types of uncertainties in transport modeling, we also argue that Sampers and NNK should be complemented with a scenario analysis. Through a scenario analysis, it is possible to construct a number of plausible futures and thereby evaluate which investments are likely to pay off with respect to the demand for transportation.

8 RECOMMENDATIONS FOR FURTHER RESEARCH

During the process of writing this thesis, we have gained a deeper knowledge within the area of demand for transportation and infrastructure investments. Furthermore, we have realized that there are many aspects within these areas that can be studied. We had to limit our study in order to focus on a specific number of research questions and approaches. However, if the scope of this thesis had been larger, we would have studied the effects on demand for transportation with respect to a larger number of factors. That is, we would not have limited our survey to only measuring the effects of changes in the traveling time and mode frequency. Through our survey, we found that the factors accessibility and comfort seemed to be of great importance for all types of commuters. Therefore, we believe that these factors would be interesting to evaluate further in the same way as we evaluated changes in the traveling time and in the mode frequency.

From our interviews, we concluded that the companies mainly demand investments between Göteborg and Trollhättan due to their recruiting problems and due to their current employees' commuting situation. This conclusion is only valid for some of the large companies interviewed and hence it would be very interesting to study the use and needs for investments among smaller companies. It is possible that these smaller companies face larger problems in freight transports than in recruiting and commuting since they have fewer employees.

If more factors and a larger sample are included in the analysis, a complete scenario analysis could be performed. We believe that the use of scenario analysis within the field of transportation could be a valuable complement to current demand forecasting models.

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APPENDIX I

Guidance for encoding questionnaires

ID

100-149 = train commuters
200-216 = Car 1 commuters
300-349 = bus commuters
400-449 = Car 2 commuters

Yes or No Questions

If a commuter answered yes, the answer was encoded as 1.

If a commuter answered no, the answer was encoded as 0.

Question 1 (Q1)

Different geographical locations, that is, cities and villages, were given certain numbers in order to measure the commuters' daily commuting distance.

Göteborg	= 1
Trollhättan	= 2
Lindome	= 3
Floda	= 4
Älvängen	= 5
Alafors	= 6
Prässebo	= 7
Lilla Edet	= 8
Lödöse	= 9
Bohus	= 10
Mölndal	= 11
Nödinge	= 12
Nol	= 13
Äskekärr	= 14
Göta	= 15
Kungälv	= 16
Skepplanda	= 17
Surte	= 18

Question 6 (Q6)

If a respondent answered none, the answer was encoded as a 0

Question 10 (Q10)

In this question, the reason that the commuter chose was encoded as 1 whereas the other reasons were encoded as 0s.

Question 12 a-c (Q12)

In this question, the chosen answer was encoded as 1 whereas the other two choices were encoded as 0s.

Question 13 and question 14 (Q13 and Q14)

In these questions, the different factors were assigned the numbers that the commuters gave them, that is, a number between one and seven.

Question 15-20 (Q15-20)

In these questions, the chosen mode of transportation was encoded as 1, whereas the two other modes were encoded as 0s.

Question 21-28 (Q21-28)

In these questions, the chosen mode of transportation was encoded as 1, whereas the two other modes were encoded as 0s.

Question 29 (Q29)

Woman = 0

Man = 1

Question 30 (Q30)

In this question, the chosen age group was encoded as 1 whereas the other age groups were encoded as 0s.

APPENDIX II

Full Version of Questionnaire



School of Economics
and Commercial Law
GÖTEBORG UNIVERSITY

Questionnaire regarding commuter habits

We are two students attending the Industrial and Financial Economics programme at Handelshögskolan in Göteborg. During this fall we are writing a master thesis about infrastructure investments. Our goal is to map the demand characteristics for different infrastructure investments between Göteborg and Trollhättan.

In the following 12 questions, please mark the most appropriate answer or write your answer on the line provided by the question.

1. Please write down the starting point and the final destination for the commuting distance that you normally travel.

Starting point _____

Final destination _____

2. Do you commute to work regularly?

Yes

No

3. Do you ever work at home in order to avoid having to commute to work?

Yes

No

4. Do you have a driving license?

Yes

No

5. Do you have car access?

Yes

No

If you replied no to question number 5, please skip question number 6 and number 7 and continue to question number 8.

6. How many days per week do you use the car when going to work?

None

_____ days/week

7. Do you use a car to get to a bus- or train station when going to work?

Yes

No

8. How long time does it take you to get to work?

_____ hours _____ minutes transportation mode _____

9. If you go by train or by bus to your work, how many times per hour does that mode depart?

(If you use several transportation modes in order to get to work, please choose the number of departures for the mode that you sit on the longest time).

_____ departures/hour

*If you usually go by **car** to work, please answer question number **10a**, if you usually go by **bus** to your work, please answer question number **10b**, and if you usually go by **train** to your work, please answer question number **10c**.*

10.

a) Which is the main reason why you go by **car** to work?

It is my fastest alternative

It is my cheapest alternative (in monetary terms)

It is my most comfortable alternative

There are no suitable bus- or train connections

There are no public transportation alternatives

b) Which is the main reason why you go by **bus** to work?

It is my fastest alternative

It is my cheapest alternative (in monetary terms)

It is my most comfortable alternative

There are no suitable train connections

I have no car access

c) Which is the main reason to why you go by **train** to work?

- It is my fastest alternative
- It is my cheapest alternative (in monetary terms)
- It is my most comfortable alternative
- There are no suitable bus connections
- I have no car access

11. Are you able to influence your working hours?

- Yes
- No

12. How would a train station in Ale municipality affect you?

- It would not affect me
- It would affect me positively
- It would affect me negatively

Please answer both question number 13 and question number 14 regardless of which transportation mode you are using at the moment!

13. Which of the following factors affect you the most if you choose to go by **train** to work?

Please **rank** the importance of the following factors where the factor that is the most important to you gets number 1 and the factor that is the least important to you gets number 7.

Please answer the question even if train currently is not a possible transportation mode for you.

Please **rank** all factors and **never** use the same number twice.

Ranking

Comfort
Speed
Cost (in monetary terms)
Mode frequency
Waiting time
Few stations
Accessibility (for example, how close you live to the train station)

14. Which of the following factors affect you the most if you choose to go by **bus** to work?

Please **rank** the importance of the following factors where the factor that is the most important to you gets number 1 and the factor that is the least important to you gets number 7.

Please answer the question even if bus currently is not a possible transportation mode for you.

Please **rank** all factors and **never** use the same number twice.

Ranking

Comfort
Speed
Cost (in monetary terms)
Mode frequency
Waiting time
Few stations
Accessibility (for example, how close you live to the bus station)

In the following 6 questions, we are interested in your traveling time from home to work. Every question presents different time scenarios for car, bus, and train.

Minus sign (-) = the traveling time with the transportation mode in question will be reduced with a certain number of minutes.

Zero (0) = the traveling time with the transportation mode in question stays the same as the current traveling time between your home and your work.

In each question, please mark the transportation mode that you prefer given the specific time scenarios.

Please notice that the only factor that changes is the traveling time. Assume all transportation modes are possible, even if they are not possible for you today.

	<u>Car</u>	<u>Bus</u>	<u>Train</u>
15.	-15 min.	-10 min.	-20 min.

	<u>Car</u>	<u>Bus</u>	<u>Train</u>
16.	-15 min.	0 min.	-10 min.

	<u>Car</u>	<u>Bus</u>	<u>Train</u>
17.	-15 min.	0 min.	0 min.

	<u>Car</u>	<u>Bus</u>	<u>Train</u>
18.	0 min.	-10min.	-10 min.

	<u>Car</u>	<u>Bus</u>	<u>Train</u>
19.	0 min.	-10 min.	0 min.

	<u>Car</u>	<u>Bus</u>	<u>Train</u>
20.	0 min.	0 min.	-20 min.

In the following 8 questions, we are interested in your preference for car, bus, or train when the mode frequency changes. With mode frequency we mean the number of departures per hour from the station where you start your trip when going from home to work or from work to home. There are no given mode frequencies for car, but you can still choose this mode.

In each question, please mark the transportation mode that you prefer given the specific mode frequencies.

Please notice that the only factor that changes is the mode frequency. Assume all transportation modes are possible, even if they are not possible for you today.

	<u>Car</u>	<u>Bus</u>	<u>Train</u>
21.	-	2 times/hour	4 times/hour

22.	<u>Car</u> -	<u>Bus</u> 2 times/hour	<u>Train</u> 2 times/hour
23.	<u>Car</u> -	<u>Bus</u> 2 times/hour	<u>Train</u> same as currently
24.	<u>Car</u> -	<u>Bus</u> 4 times/hour	<u>Train</u> 2 times/hour
25.	<u>Car</u> -	<u>Bus</u> 4 times/hour	<u>Train</u> 4 times/hour
26.	<u>Car</u> -	<u>Bus</u> 4 times/hour	<u>Train</u> same as currently
27.	<u>Car</u> -	<u>Bus</u> same as currently	<u>Train</u> 2 times/hour
28.	<u>Car</u> -	<u>Bus</u> same as currently	<u>Train</u> 4 times/hour

A few questions about you

29. Gender?

Woman

Man

30. How old are you?

18 - 24 years old

25 - 44 years old

45 - 64 years old

65 years old or older

Thank you for your participation! Your contribution to our survey means a lot to us!

/Anna Boström & Anneli Axsäter

APPENDIX III

Short Version of Questionnaire



School of Economics
and Commercial Law
GÖTEBORG UNIVERSITY

Questionnaire regarding commuter habits

We are two students attending the Industrial and Financial Economics programme at Handelshögskolan in Göteborg. During this fall we are writing a master thesis about infrastructure investments. Our goal is to map the demand characteristics for different infrastructure investments between Göteborg and Trollhättan.

1. Please write down the starting point and the final destination for the commuting distance that you normally travel.

Starting point _____

Final destination _____

2. Which is the main reason why you go by **car** to work?

It is my fastest alternative

It is my cheapest alternative (in monetary terms)

It is my most comfortable alternative

There are no suitable bus- or train connections

There are no public transportation alternatives

3. How would a train station in Ale municipality affect you?

It would not affect me

It would affect me positively

It would affect me negatively

Please answer both question number 4 and question number 5 regardless of which transportation mode you are using at the moment!

4. Which of the following factors affect you the most if you choose to go by **train** to work?

Please **rank** the importance of the following factors where the factor that is the most important to you gets number 1 and the factor that is the least important to you gets number 7.

Please answer the question even if train currently is not a possible transportation mode for you.

Please **rank** all factors and **never** use the same number twice.

Ranking

Comfort
Speed
Cost (in monetary terms)
Mode frequency
Waiting time
Few stations
Accessibility (for example, how close you live to the train station)

5. Which of the following factors affect you the most if you choose to go by **bus** to work?

Please **rank** the importance of the following factors where the factor that is the most important to you gets number 1 and the factor that is the least important to you gets number 7.

Please answer the question even if bus currently is not a possible transportation mode for you.

Please **rank** all factors and **never** use the same number twice.

Ranking

Comfort
Speed
Cost (in monetary terms)
Mode frequency
Waiting time
Few stations
Accessibility (for example, how close you live to the bus station)

6. How old are you?
18 - 24 years old
25 - 44 years old
45 - 64 years old
65 years old or older

Thank you for your participation! Your contribution to our survey means a lot to us!

/Anna Boström & Anneli Axsäter

APPENDIX IV

Output from Limdep: Time

```
nlogit;  
lhs=choice;  
choices=bil,buss,tag/0.145,0.427,0.427;  
rhs=time;  
rh2=q1a,q1b,q8hours,q29,q30a,q30b,q30c,q30d,q11,q5;  
effects:time(*)$          ?ger elasticiteter
```

Normal exit from iterations. Exit status=0.

```
+-----+  
| Discrete choice (multinomial logit) model |  
| Maximum Likelihood Estimates             |  
| Model estimated: Nov 19, 2003 at 01:43:04PM. |  
| Dependent variable      Choice          |  
| Weighting variable      None           |  
| Number of observations   678           |  
| Iterations completed    39            |  
| Log likelihood function  -506.9978     |  
| Log-L for Choice model = -506.99779    |  
| R2=1-LogL/LogL* Log-L fncn R-sqrd RsqAdj |  
| Constants only. Must be computed directly. |  
|      Use NLOGIT ;...; RHS=ONE $ |  
| Vars. corrected for choice based sampling |  
| Response data are given as ind. choice. |  
| Number of obs.= 702, skipped 24 bad obs. |  
+-----+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[Z >z]
TIME	.8972709350E-01	.63078864E-02	14.225	.0000
BILxQ1A1	.1634201094	.66658523E-01	2.452	.0142
BILxQ1B1	.8794028141E-02	.57401800E-01	.153	.8782
BILxQ8H1	-1.643751861	.52185281	-3.150	.0016
BILxQ291	1.014891986	.33740875	3.008	.0026
BILxQ301	-2.160958089	1.1013327	-1.962	.0497
BILxQ301	-2.160958089	1.1013327	-1.962	.0497
BILxQ301	-2.160958089	1.1013327	-1.962	.0497
BILxQ301	-2.160958089	1.1013327	-1.962	.0497
BILxQ111	1.740897274	.73051122	2.383	.0172
BILxQ51	.5163973083	.42212217	1.223	.2212
BUSxQ1A2	.1946760003	.29107224E-01	6.688	.0000
BUSxQ1B2	.2014295280	.22606263E-01	8.910	.0000
BUSxQ8H2	-4151935328	.17337740	-2.395	.0166
BUSxQ292	-2737648240	.12500175	-2.190	.0285
BUSxQ302	-5462023072	.35860809	-1.523	.1277
BUSxQ302	-5462023072	.35860809	-1.523	.1277
BUSxQ302	-5462023072	.35860809	-1.523	.1277
BUSxQ302	-5462023072	.35860809	-1.523	.1277
BUSxQ112	-4633912331	.17118740	-2.707	.0068
BUSxQ52	-1000520328	.13475312	-.742	.4578

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```

+-----+
| Partial effects = average over observations          |
|                                                     |
|  $\frac{d \ln P[\text{alt}=k, \text{br}=j, \text{lmb}=i, \text{tr}=l]}{dx(m): \text{alt}=K, \text{br}=J, \text{lmb}=I, \text{tr}=L}$  =  $D(m:K,J,I,L) = \text{delta}(m) * F$  |
|                                                     |
|  $\text{delta}(m)$  = coefficient on  $x(m)$  in  $U(K:J,I,L)$       |
|  $F = (l=L) (i=I) (j=J) [(k=K)-P(K:JIL)]$           |
| +  $(l=L) (i=I) [(j=J)-P(J:IL)] P(K:JIL)t(J:IL)$    |
| +  $(l=L) [(i=I)-P(I:L)] P(J:IL) P(K:JIL)t(J:IL)s(I:L)$  |
| +  $[(l=L)-P(L)] P(I:L) P(J:IL) P(K:JIL)t(J:IL)s(I:L)f(L)$  |
|                                                     |
|  $P(K|JIL) = \text{Prob}[\text{choice}=K | \text{branch}=J, \text{limb}=I, \text{trunk}=L]$  |
|  $P(J|IL), P(I^3L), P(L)$  defined likewise.        |
|  $(n=N) = 1$  if  $n=N$ , 0 else, for  $n=k,j,i,l$  and  $N=K,J,I,L$ . |
| Elasticity =  $x(l) * D(l:K,J,I)$                   |
| Marginal effect =  $P(K|JIL) * D = P(K:JIL)P(J:IL)P(I:L)P(L)D$  |
|  $F$  is decomposed into the 4 parts in the tables.    |
+-----+

```

Elasticity Averaged over observations.

Attribute is TIME in choice BIL

Effects on probabilities of all choices in the model:

* indicates direct Elasticity effect of the attribute.

Decomposition of Effect

	Trunk	Limb	Branch	Choice	Total
* Choice=BIL	.000	.000	.000	.501	.501
Choice=BUSS	.000	.000	.000	-.171	-.171
Choice=TAG	.000	.000	.000	-.171	-.171

Elasticity Averaged over observations.

Attribute is TIME in choice BUSS

Effects on probabilities of all choices in the model:

* indicates direct Elasticity effect of the attribute.

Decomposition of Effect

	Trunk	Limb	Branch	Choice	Total
Choice=BIL	.000	.000	.000	-.191	-.191
* Choice=BUSS	.000	.000	.000	.258	.258
Choice=TAG	.000	.000	.000	-.191	-.191

Elasticity Averaged over observations.

Attribute is TIME in choice TAG

Effects on probabilities of all choices in the model:

* indicates direct Elasticity effect of the attribute.

Decomposition of Effect

	Trunk	Limb	Branch	Choice	Total
Choice=BIL	.000	.000	.000	-.556	-.556
Choice=BUSS	.000	.000	.000	-.556	-.556
* Choice=TAG	.000	.000	.000	.342	.342

APPENDIX V

Output from Limdep: Frequency

```
nlogit;
lhs=choice;
choices=bil,buss>tag/0.145,0.427,0.427;
rhs=freq;
rh2=q1a,q1b,q8hours,q29,q30a,q30b,q30c,q30d,q11,q5;
effects:freq(*)$          ?ger elasticiteter
```

Normal exit from iterations. Exit status=0.

```
+-----+
| Discrete choice (multinomial logit) model |
| Maximum Likelihood Estimates             |
| Model estimated: Nov 19, 2003 at 01:57:12PM. |
| Dependent variable      Choice          |
| Weighting variable      None           |
| Number of observations   904            |
| Iterations completed    24             |
| Log likelihood function  -667.7065     |
| Log-L for Choice model = -667.70654    |
| R2=1-LogL/LogL* Log-L fncn R-sqrd RsqAdj |
| Constants only. Must be computed directly. |
|      Use NLOGIT ;...; RHS=ONE $ |
| Vars. corrected for choice based sampling |
| Response data are given as ind. choice. |
| Number of obs.= 936, skipped 32 bad obs. |
+-----+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[Z >z]
FREQ	.5133771212	.33928406E-01	15.131	.0000
BILxQ1A1	.1702814650	.57197655E-01	2.977	.0029
BILxQ1B1	.1097499464	.44938097E-01	2.442	.0146
BILxQ8H1	-1.448305693	.41493140	-3.490	.0005
BILxQ291	1.069223808	.27101354	3.945	.0001
BILxQ301	-1.281647175	.88984113	-1.440	.1498
BILxQ301	-1.281647175	.88984113	-1.440	.1498
BILxQ301	-1.281647175	.88984113	-1.440	.1498
BILxQ301	-1.281647175	.88984113	-1.440	.1498
BILxQ111	.8301053931	.48845896	1.699	.0892
BILxQ51	.1615008111	.29247947	.552	.5808
BUSxQ1A2	.2365907513	.31167761E-01	7.591	.0000
BUSxQ1B2	.2534528092	.27303816E-01	9.283	.0000
BUSxQ8H2	-.5805885321	.19913319	-2.916	.0036
BUSxQ292	-.1624898878	.13884360	-1.170	.2419
BUSxQ302	-1.237725921	.41423534	-2.988	.0028
BUSxQ302	-1.237725921	.41423534	-2.988	.0028
BUSxQ302	-1.237725921	.41423534	-2.988	.0028
BUSxQ302	-1.237725921	.41423534	-2.988	.0028
BUSxQ112	-.4064328829	.20408585	-1.991	.0464
BUSxQ52	-.6274227880E-01	.16572100	-.379	.7050

(Note: E+nn or E-nn means multiply by 10 to + or -nn power.)

```

+-----+
| Partial effects = average over observations          |
|                                                     |
|  $\frac{d \ln P[\text{alt}=k, \text{br}=j, \text{lmb}=i, \text{tr}=l]}{dx(m): \text{alt}=K, \text{br}=J, \text{lmb}=I, \text{tr}=L}$  =  $D(m:K,J,I,L) = \text{delta}(m) * F$  |
|-----|
|  $\text{delta}(m)$  = coefficient on  $x(m)$  in  $U(K:J,I,L)$       |
|  $F = (l=L) (i=I) (j=J) [(k=K)-P(K:JIL)]$           |
| +  $(l=L) (i=I) [(j=J)-P(J:IL)] P(K:JIL)t(J:IL)$     |
| +  $(l=L) [(i=I)-P(I:L)] P(J:IL) P(K:JIL)t(J:IL)s(I:L)$  |
| +  $[(l=L)-P(L)] P(I:L) P(J:IL) P(K:JIL)t(J:IL)s(I:L)f(L)$  |
|                                                     |
|  $P(K|JIL) = \text{Prob}[\text{choice}=K \mid \text{branch}=J, \text{limb}=I, \text{trunk}=L]$  |
|  $P(J|IL), P(I^3L), P(L)$  defined likewise.          |
|  $(n=N) = 1$  if  $n=N$ , 0 else, for  $n=k,j,i,l$  and  $N=K,J,I,L$ . |
| Elasticity =  $x(l) * D(l:K,J,I)$                     |
| Marginal effect =  $P(K|JIL) * D = P(K:JIL)P(J:IL)P(I:L)P(L)D$  |
| F is decomposed into the 4 parts in the tables.      |
+-----+

```

Elasticity Averaged over observations.

Attribute is FREQ in choice BUSS

Effects on probabilities of all choices in the model:

* indicates direct Elasticity effect of the attribute.

Decomposition of Effect

	Trunk	Limb	Branch	Choice	Total
Choice=BIL	.000	.000	.000	-.517	-.517
* Choice=BUSS	.000	.000	.000	.638	.638
Choice=TAG	.000	.000	.000	-.517	-.517

Elasticity Averaged over observations.

Attribute is FREQ in choice TAG

Effects on probabilities of all choices in the model:

* indicates direct Elasticity effect of the attribute.

Decomposition of Effect

	Trunk	Limb	Branch	Choice	Total
Choice=BIL	.000	.000	.000	-.710	-.710
Choice=BUSS	.000	.000	.000	-.710	-.710
* Choice=TAG	.000	.000	.000	.445	.445

APPENDIX VI

Interview Guide

1. How do you perceive employees' current commuting situation and could it be affected by infrastructure investments in R45 and Norge/Vänernbanan?
2. How would you describe the company's current recruitment situation and could it be improved by an infrastructure investment in R45 and Norge/Vänernbanan?
3. Would investments in R45 and Norge/Vänernbanan affect the company's strategies regarding potential new investments and future developments?
4. Would the company's competitive situation be affected by investments in R45 and Norge/Vänernbanan?
5. What is the company's current and future approximate freight volume per day in terms of the number of train sets and trucks?
6. How large are the company's freight volumes on R45 and Norge/Vänernbanan in comparison to other roads and railways?
7. Does the company experience any problems when or if it carries freight on R45 or Norge/Vänernbanan?
8. Would investments in R45 and Norge/Vänernbanan solve these possible problems?
9. Would the company consider changing its current choice of transportation mode when carrying freight if investments in R45 and Norge/Vänernbanan were undertaken?

APPENDIX VII

Choices with Respect to Changes in Traveling Time

Train Commuters:

Choice	Number of commuters	Percentage of commuters
Car	33	11%
Bus	10	3%
Train	254	85%
Incomplete	3	1%

Car Commuters:

Choice	Number of commuters	Percentage of commuters
Car	80	78%
Bus	0	0%
Train	22	22%

Bus commuters:

Choice	Number of commuters	Percentage of commuters
Car	51	17%
Bus	93	31%
Train	156	52%

Choices with Respect to Changes in Mode Frequency

Train Commuters:

Choice	Number of commuters	Percentage of commuters
Car	19	4,8%
Bus	23	5,8%
Train	358	90%

Car Commuters:

Choice	Number of commuters	Percentage of commuters
Car	79	58%
Bus	13	10%
Train	44	32%

Bus Commuters:

Choice	Number of commuters	Percentage of commuters
Car	61	15%
Bus	169	42%
Train	170	43%

APPENDIX VIII

Concept of Elasticity

When measuring responsiveness to changes in supply and demand the concept of elasticity is used. Elasticity is a general concept that can be used to quantify the response in one variable when another variable changes. For example, one can calculate the elasticity of demand or supply with respect to the price. If variable **A** changes in response to changes in variable **B**, the elasticity of **A** with respect to **B** is equal to the percentage change in **A** divided by the percentage change in **B**, which is shown in the following formula:

$$\text{Elasticity}_A = \frac{\% \Delta A}{\% \Delta B}$$

The percentage changes should always carry a plus or a minus sign before the ratio. Positive changes, or increases, result in a plus sign. Negative changes, or decreases, result in a minus sign. For example, the law of demand implies that price elasticity of demand is nearly always a negative number since price increases (+) will lead to decreases in quantity demanded (-), and vice versa. The resulting ratio is the own price elasticity, which is the percentage change in quantity demanded or quantity supplied in response to a 1% change in the price⁸⁶.

Cross Elasticity of Demand

There are several factors affecting the demand elasticity. However, two of the most obvious factors affecting demand elasticity are probably the availability of substitutes and the availability of complements. The responsiveness of the quantity demanded of a particular good to the prices of its substitutes and complements is measured by cross elasticity of demand. Cross price elasticities could, for example, be described as the percentage change in the quantity demanded for train services in response to a percentage change in the price of bus tickets.

⁸⁶ Samuelson (1980)

The cross elasticity of demand is calculated in the following way:

$$CrossElasticity_A = \frac{\% \Delta Q_A}{\% \Delta P_B}$$

Where $\% \Delta Q_A$ is equal to the percentage change in quantity demanded of good A and where $\% \Delta P_B$ is equal to the percentage change in the price of good B⁸⁷.

Elasticities and Cross Elasticities with Respect to Other Factors

The concept of elasticity and cross elasticities could also be applied on other factors than price when studying the effect of certain changes and its effect on the demand for transportation. It is possible to estimate quality elasticities and cross elasticities, which deal with the responsiveness of demand to changes in quality. For example, one is able to quantify the effect on demand through changes in traveling time and in waiting time.

The concept of demand elasticities for transportation is further complicated by mode choice elasticities. Many transportation demand studies try to estimate the distribution or split of a fixed volume of traffic among different modes. These studies produce elasticities between modes, but they differ from ordinary demand elasticities in the way that they do not take into account the effect of a transport price change on the aggregate volume of traffic, but only the distribution between modes⁸⁸.

For more detailed information about elasticities, cross elasticities, and the application of these within transport modeling, please take a closer look in basic economics textbooks, such as “*Economics*” written by Paul A. Samuelson and in “*Handbook of Transport Modelling*” written by David A. Hensher and Kenneth J. Button.

⁸⁷ Samuelson (1980)

⁸⁸ Hensher & Button (2000)

APPENDIX IX

Effects on Demand of Changes in Traveling Time

Choice	Elasticity	Cross elasticities		
		Car	Bus	Train
Bus	0,258	-0,191	NA	-0,191
Train	0,342	-0,556	-0,556	NA

The elasticity among bus commuters with respect to the traveling time for bus is 0,258. This implies that if the reduction in the traveling time by bus increases by 1%, the probability among bus commuters of choosing bus increases by 0,258%. The cross elasticities among car and train commuters with respect to a change in the traveling time by bus are -0,191 respectively, which means that the probabilities of choosing car and train among car and train commuters will decrease by 0,191% if the reduction in the traveling time by bus increases by 1%.

The elasticity among train commuters is 0,342 and the cross elasticities for car and bus among car and bus commuters with respect to a change in the traveling time for train are -0,556 respectively. The elasticity among train commuters implies that if the reduction in the traveling time by train increases by 1%, the probability of choosing train increases by 0,342% among those train commuters. The cross elasticities for car and bus among car and bus commuters mean that if the reduction in the traveling time by train increases by 1%, the probabilities of choosing car and bus will decrease by 0,556% in both of these two commuter groups.

Effects on Demand of Changes in Mode Frequency

Choice	Elasticity	Cross elasticities		
		Car	Bus	Train
Bus	0,638	-0,517	NA	-0,517
Train	0,445	-0,710	-0,710	NA

The elasticity among bus commuters is 0,638, which implies that if the mode frequency increases by 1%, the probability among bus commuters of choosing bus increases by 0,542%. The cross elasticities among car and train commuters with respect to a change in the mode frequency for bus are $-0,517$. These cross elasticities mean that if the mode frequency for bus increases by 1%, the probabilities of choosing either car or train decrease by 0,517% in both groups of commuters.

The elasticity among train commuters with respect to a change in the mode frequency for train is 0,445, which shows that if the mode frequency for train increases by 1%, the probability of choosing train among train commuters increases by 0,445%. The cross elasticities among car and bus commuters with respect to a change in the mode frequency for train are $-0,710$ and these imply that the probabilities of choosing car or bus will decrease by 0,710% among car and bus commuters respectively if the mode frequency for train increases by 1%.