CHALMERS
UNIVERSITY OF TECHNOLOGY

A Study of Multimodality with Focus on the Combination of Bicycles and Trains

Technical Solutions Combined with Mobility Management and Nudging for an Effective Bicycle-Train System in Region Västra Götaland

Master's thesis in Infrastructure and Environmental Engineering

ALMA SJÖÖ
LINA SKÖLDBERG

Department of Architecture and Civil Engineering
Division of Geology and Geotechnics
Urban Mobility Systems Research Group
CHALMERS UNIVERSITY OF TECHNOLOGY
Master's Thesis ACEX30-19-23
Gothenburg, Sweden 2019

MASTER’S THESIS ACEX30-19-23

A Study of Multimodality with Focus on the Combination of Bicycles and Trains

Technical Solutions Combined with Mobility Management and Nudging for an Effective Bicycle-Train System in Region Västra Götaland

Master’s Thesis in the Master’s Programme Infrastructure and Environmental Engineering

ALMA SJÖÖ
LINA SKÖLDBERG

Department of Architecture and Civil Engineering
Division of Geology and Geotechnics
Urban Mobility Systems Research Group
CHALMERS UNIVERSITY OF TECHNOLOGY

Göteborg, Sweden 2019

A Study of Multimodality with Focus on the Combination of Bicycles and Trains
Technical Solutions Combined with Mobility Management and Nudging for an Effective Bicycle-Train System in Region Västra Götaland

Master's Thesis in the Master's Programme Infrastructure and Environmental Engineering

ALMA SJÖÖ

LINA SKÖLDBERG

Examensarbete ACEX30-19-23
Institutionen för arkitektur och samhällsbyggnadsteknik
Chalmers tekniska högskola, 2019

Department of Architecture and Civil Engineering
Division of Geology and Geotechnics
Urban Mobility Systems Research Group
Chalmers University of Technology
SE-412 96 Göteborg
Sweden
Telephone: + 46 (0)31-772 1000

Department of Architecture and Civil Engineering
Göteborg, Sweden, 2019

A Study of Multimodality with Focus on the Combination of Bicycles and Trains
Technical Solutions Combined with Mobility Management and Nudging for an Effective Bicycle-Train System in Region Västra Götaland

Master's thesis in the Master's Programme Infrastructure and Environmental Engineering

ALMA SJÖÖ

LINA SKÖLDBERG

Department of Architecture and Civil Engineering
Division of Geology and Geotechnics
Urban Mobility Systems Research Group
Chalmers University of Technology

ABSTRACT

The aim of the report is to evaluate possibilities and challenges regarding bicycles on trains, and to apply the found knowledge to a case in the Region Västra Götaland. The goal is to combine technical measures with Mobility Management and Nudging to promote the possibility. A literature study was conducted to explore the concept of multimodality and the use of services for door-to-door trips. A bicycle-train system is a viable option where both modes are sustainable and time efficient. Examples of implementations from Denmark, The Netherlands and the three big city regions in Sweden were explored. Technical measures were investigated regarding how the train and station environments should be created. The most commonly used are bicycle stands under foldable chairs or different hanging functions. Different Mobility Management and Nudging measures were further discussed. Examples of these are informational measures like implementation of real-time signs or marketing measures such as campaigns with trial bicyclists. A survey was created and distributed in order to obtain information regarding the habits and views of travellers. The survey was performed in Sweden's three big city regions; Gothenburg, Stockholm and Malmö. The outcome was that not many bring their bicycle on the train but that a larger share is interested in the possibility if it were to be improved. The outcome was analysed in a regression model that was used to create focus groups and areas. This showed that the most important age groups are 20-29 and 40-49. Furthermore, it showed that the distance to the station is important whereas gender was not. It was discussed that since Mobility Management and Nudging are relatively new concepts within the transport sector, it was difficult to evaluate the effectiveness of proposed measures. The report concluded in a package of measures. Hard measures expand capacity without affecting other passengers too much, through shared spaces with possibilities to fasten the bicycles. Clear information and communication are important in all stages. The number of spaces should be in line with a proposed EU guideline of a minimum of eight dedicated spaces.

Key words:
Mobility Management, Nudging, Bicycle-Train System, Multimodality, Public transport, Bicycles

En Studie av Multimodalitet med Fokus på Kombinationen av Cykel och Tåg

Tekniska Lösningar Kombinerat med Mobility Management och Nudging för ett Effektivt Cykel-Tåg System i Västra Götalandsregionen

Examensarbete inom mastersprogrammet Infrastruktur och Miljöteknik

ALMA SJÖÖ

LINA SKÖLDBERG

Institutionen för arkitektur och samhällsbyggnadsteknik
Avdelningen för Geologi och Geoteknik
Väg och trafik
Chalmers tekniska högskola

SAMMANFATTNING

Syftet med rapporten är att utvärdera möjligheter och svårigheter angående cyklar på tåg och sedan applicera kunskapen till ett case i Västra Götalandsregionen. Målet är att kombinera tekniska lösningar med Mobility Management och Nudging för att marknadsföra möjligheten. En litteraturstudie genomfördes för att utforska konceptet multimodalitet och användandet av olika medel för resor dörr-till-dörr. Ett cykel-tågsystem är ett bra alternativ där båda transportmedlen är hållbara och effektiva tidsmässigt. Exempel från implementering i Danmark, Nederländerna samt Sveriges tre storstadsregioner undersöktes. Tekniska lösningar undersöktes angående hur tågen och stationsmiljöerna borde utformas. Den mest använda lösningen är cykelställ under fällbara säten eller olika upphängningsanordningar. Vidare diskuteras olika Mobility Management- och Nudging-åtgärder. Exempel på detta är informationsåtgärder såsom implementering av realtidsskyltar eller marknadsföringsåtgärder såsom kampanjer med testcyklare. Dessutom utformades en enkät och spreds för att få information om resvanor och åsikter från pendlare. Enkäten skickades ut till Sveriges tre storstadsregioner; Göteborg, Stockholm och Malmö. Resultatet var att få tar med sig cykel på tåget i nuläget men att många är intresserade av möjligheten om den förbättras. Resultatet från enkäten analyserades i en regressionsmodell som användes för att identifiera fokusområden och -grupper. Slutsatsen av detta var att de viktigaste ålderskategorierna är spannen 20–29 samt 40–49. Den visade också att avståndet till stationen är viktig samtidigt som kön inte spelade roll. Det diskuterades att eftersom Mobility Management och Nudging är relativt nya koncept inom transportsektorn var det svårt att utvärdera effektiviteten av de föreslagna åtgärderna. Rapporten slutade i ett åtgärdspaket. Tekniska åtgärder som ökar kapaciteten för cyklar utan att påverka resterande passagerare märkbart är delade utrymmen med möjlighet att fästa cykeln. Tydlig information och kommunikation är viktigt i alla steg. Antalet cykelplatser på tågen borde ligga i linje med EU-förslaget på minimalt 8 dedikerade platser per tåg-set.

Nyckelord: Mobility Management, Nudging, Cykel-Tåg System, Multimodalitet, Kollektivtrafik, Cyklar

Contents

ABSTRACT I

SAMMANFATTNING II

CONTENTS III

PREFACE V

1 INTRODUCTION 1

1.1 Background 2

1.2 Aim and Objectives 2

1.3 Limitations 3

2 METHODOLOGY 4

2.1 Literature Study 4
2.1.1 Interviews 4

2.2 Survey 4

2.3 Binomial Logistic Regression Model 5
2.3.1 Mathematical Framework 6
2.3.2 SPSS Software 7
2.3.3 Model Setup 9

2.4 Data Analysis 10

3 LITERATURE STUDY 11

3.1 Transportation Systems 11
3.1.1 Transportation Modes 11
3.1.2 Multimodality 12
3.1.3 Examples for Implementation of Hard Measures 15

3.2 Current Situation in Different Cities 18
3.2.1 Sweden 19
3.2.2 The Netherlands: Amsterdam 27
3.2.3 Denmark: Copenhagen 28
3.2.4 Previous Survey for the Swedish Transport Administration 30

3.3 Soft Measures 31
3.3.1 Mobility Management 32
3.3.2 Nudging 34
3.3.3 Effectiveness of Soft Measures 36
3.3.4 Examples for Implementation of Soft Measures 38

4 RESULTS OF SURVEY 44

4.1 Outcome of Survey 44

4.2 Binomial Logistic Regression Model 49
4.2.1 Statistical Significance 50

4.2.2 Calculations 53
4.3 Data Analysis 56

5 DISCUSSION 61
5.1 Hard measures 61
5.2 Different Cities 62
5.3 Soft Measures 63
5.4 Survey 64
5.5 Binomial Logistic Regression Model 65
5.6 Total Data Analysis 66
5.7 Package of Measures for Region Västra Götaland 67
5.8 Additional Thoughts 69

6 CONCLUSION 71

REFERENCES 72

APPENDIX I – ORIGINAL SURVEY IN SWEDISH 78

APPENDIX II – SURVEY TRANSLATED 81

APPENDIX III – CALCULATIONS OF PROBABILITIES 84

APPENDIX IV – EXCERPT FROM *RAIL PASSENGERS' RIGHTS AND OBLIGATIONS*, EUROPEAN PARLIAMENT 85

Preface

The thesis work was carried out at Ramboll's office in Gothenburg. We would like to thank our supervisors Sara Johansson and Karin Blomsterberg for guiding us with suggestions and feedback throughout the semester, together with other employees with interest of thoughts about the subject. We are also grateful to our supervisor at Chalmers, Ivana Tasic, who came up with multiple interesting ideas along the way of how to develop the thesis.

Furthermore, thanks to everyone who took the time to answer the survey that worked as a foundation for this report, Ramboll employees as well as others. Without those answers the report would not have been complete.

We would also like to thank the people at Västtrafik for taking the time to meet us for an interview that allowed us deeper knowledge. Moreover, appreciations are directed to the responsible people at Metro in Copenhagen and at Region Stockholm for answering our emails with questions about their views of the matter.

Lastly, we are grateful towards the opponents of this report, Johanna Greger and Linus Wrede, who provided helpful comments and feedback before the completion of the thesis.

Göteborg, June 2019

Alma Sjöö and Lina Sköldberg

1 Introduction

The primary challenge of passenger transport is today the great extent of car use (Mont, Lehner, & Heiskanen, 2014). In order to obtain more sustainable mobility habits while simultaneously accomplishing the same level of convenience as using cars, the right conditions for infrastructure, products and physical environment must be fulfilled. Even though politicians and planners have realised that the car cannot be used in the same manner and extent in the future as today, the standard for transport planning and usage has not changed (Hiselius & Rosqvist, 2016). Mobility Management (MM) and Nudging are complements to traditional transport planning through their concept of behavioural influence within the transport department (EPOMM, 2013; Thaler & Sunstein, 2008). Through information and utilisation of soft skills, the aim is to increase the effectiveness of the infrastructure and use of transports. The purpose is to affect the desired change before implementation of a technical solution or in combination with it. Hence, Mobility Management and Nudging are tools most often not replacing nor excluding technical solutions but used to amplify the effect of existing or new technology.

The use of sustainable transportation is desirable to reduce negative urban transportation by changing travel behaviour to sustainable modes (Küster, Lancaster, & Tusl, 2016). To be competitive against cars in accessibility, several sustainable modes may be combined to multimodal trips. The concept of multimodality refers to trips where two or more transport modes are used to fulfil a door-to-door service. This thesis explores the interest in combining bicycles with public transport which is increasing, plausibly influencing future procurements of buses and trains (Trafikverket, 2016, 2017) as this combination is one of the most environmentally friendly alternative for longer distance trips (Küster et al., 2016). Carrying a bicycle on a commuting trip to be used within the city as well could unburden the local public transportation somewhat (Regeringskansliet, 2017). An additional advantage with bicycle use is that the individual health and flexibility advantages are increased (Rojas-Rueda et al., 2016). Hence, this thesis is studying which methods that can increase the use of bicycles for commuters, as they are most probably reliable on public transport within the city.

The popularity of cycling in general is growing in the European Union which in turn is affecting the demand of mobility (European Parliament, 2018). Bicycle sharing systems are popular and easy to use for the First Mile/Last Mile (FMLM) (X. C. Liu, Porter, Zlatkovic, Fayyaz, & Taylor, 2018) of a journey within the city, consequently serving as a healthy alternative to public transport (Z. Liu, Jia, & Cheng, 2012). For people commuting longer distances each day, between municipalities further than within normal biking distance, commuting trains are popular to use. There are multiple benefits of commuting by train rather than car, such as more environmentally friendly and having time to use for reading for instance (Robson, 2018). Yet, the methods and accessibility for FMLM transport modes varies a lot. Some use a car and to leave outside the city in commuting parking lots and travel by train or bus the last distance, avoiding traffic jams closer to the city centre (Göteborgs Stad, n.d.). Others have the possibility to walk or cycle. Nevertheless, there is a need to use a third transport mode after the train trip segment when in the city centre, whether it is walking, cycling or public transportation for instance. The use of bicycles for FMLM mode can be done in different ways. This thesis' main goal is to investigate properties, possibilities and demand for bringing bicycles on board the commuting trains in Region Västra Götaland, as a part of improving public health and environmental benefits.

1.1 Background

According to Region Västra Götaland (Kollektivtrafiksekretariatet, 2013), new travel behaviour and views of traveling in general are needed to manage a readjustment to a sustainable transportation system. A private car is on average used for 48 minutes per day and is parked during the remainder of the time, demanding space (Kollektivtrafiksekretariatet, 2013). The awareness of the car's impact is showing on shifting attitudes among younger people, as they are less dependent on cars and the need of owning a personal car is generally lower with age (EPOMM, 2013). The personal value of a car is commonly decreasing, as long as the accessibility is unaffected. The attitudes must however change on a larger scale for results to show. To increase the share using public transportation and hence decrease the number of cars, public transport must be considered attractive (Kollektivtrafiksekretariatet, 2013). Quality, image and impression are decisive factors for people's choices. A great argument for cycling is the improved health condition since regular exercise has positive effects on both physical and mental health.

The travel mode train counts as a sustainable mode, and often make up the larger part of the urban transportation network in major cities such as Stockholm. A condition for train trips is the rail infrastructure's ability to expand the train services. A study comparing the train service supply for regions in Sweden showed that Västra Götaland is one of the regions offering the least supply-kilometre train per inhabitant (VGR, 2016). The low service is depending on the limited capacity of the infrastructure. Expanding the infrastructure to give faster and better train connections would contribute to a more integrated region according to VGR and, from that, also growth and increased source of revenue. A calculation performed by the School of Economics in Jönköping showed that a progress of the regional train services as described in *Målbild Tåg 2035*, i.e. *Vision Train 2035*, (Kollektivtrafiksekretariatet, 2013) gave an annual production output increase worth 2 billion SEK for Region Västra Götaland. Furthermore, regional politicians agree with the notion that sustainable travel by public transport should be developed in order to reach the aim of being a competitive and appealing region.

As a part of the regional plan for transport infrastructure, the *Strategy for increased cycling* (Mattsson, Sundberg, & Nilsson, 2016) claims that the bicycle has high potential to replace short trips made by car. Many trips made in the urban areas are shorter than five kilometres yet only 6 percent of trips in Västra Götaland are made by bicycle. That is one of the lowest numbers for regions in Sweden. According to Mattsson et al. (2016) trip combinations of bicycle and train can be a competitive option to the car, if the right circumstances are given.

1.2 Aim and Objectives

The goal is to recommend a package of measures, including technical solutions and soft measures, on how to best implement a functional connection and established bicycle-train system for commuters in Region Västra Götaland based on the regional situation. To gain this information, some questions are sought to be answered:

- How does the current situation in Region Västra Götaland for the combination of trains and bicycles look like, and to what extent are bicycles brought on board?
- What are the future prospects of Region Västra Götaland regarding a bicycle-train system?
- What are the reasons for people that do or do not use the possibility now?
- How does the Gothenburg region case compare to other Swedish and international regions? Are there examples from other places that could be implemented in Gothenburg, and has there been a confirmed increase in cyclists from those examples?
- Which specific technical measures exist that can improve the current situation? In what ways can the capacity of bringing bicycles on trains be increased?
- What is Mobility Management? Can MM and other soft measures influence transport behaviour and more specifically be implemented in this case?

1.3 Limitations

To frame the thesis, some limitations were set up as described below.

- The thesis only investigates the bicycle-train system for when bringing a bicycle on board a train, not thoroughly analysing other possibilities of the combination.
- The survey was limited to Sweden’s big city regions; Stockholm, Gothenburg and Malmö.
- Gothenburg is the focal area for the package of measures.
- The Nudging measures investigated were only those regarding personal transport and the soft measures were those applicable to this case of bringing bicycles on board trains.
- The cost of the technical measures was generally disregarded when combining a package of measures.

2 Methodology

A literature study was performed for information about the existing situation. Furthermore, a survey was developed to gain insight about the public's travel habits and attitudes of bringing bicycles on trains. The results were then analysed through a statistical logistic regression model as well as a more general analysis. The regression model was performed to gain target groups for which Mobility Management and Nudging were deemed to be more effective. Examples of both hard and soft measures were investigated and those suiting to the Gothenburg area combined for an effective bicycle-train system in the Gothenburg area. Site visits to the central station of Gothenburg, as well as on selected Västtåg were performed. Visual observations were additionally done around Gothenburg for existing signage and information.

2.1 Literature Study

Information was gathered regarding theory and practical uses of the combination of bicycles and trains as well as considering soft measures, in general and related to the specific topic. Furthermore, examples and studies of the bicycle and train combination were examined to find accurate approaches and measures. Information was collected from Västtrafik as well as other relevant authorities regarding the current situation in Gothenburg. This situation in Region Västra Götaland was compared to countries and cities with a higher bicycle share, Denmark and The Netherlands, by searching information regarding the information and contacting relevant authorities if necessary.

The literature study was based on information from several different kinds of sources. Internet sources were used to obtain as new information as possible, while hardcovers were consulted for generally accepted facts. Foremost, reports were used as foundation for the literature study. Specifically, EPOMM (the European Platform On Mobility Management) was mostly used when regarding Mobility Management and the book *Nudge* which coined the expression for information about Nudging. The existing situation of the example cities were mainly based on train operators' web pages, but emails were exchanged for when information was lacking.

2.1.1 Interviews

To complement the literature search and review, several interviews were conducted to obtain more specific information. Questions were sent out to the responsible rail organisations in Sweden, Denmark and The Netherlands. Most interviews were conducted by email to the Swedish Transport Administration (Trafikverket), Region Skåne, SL, VGR, DSB, MetroDK and NS. All were contacted by email yet not all responded. The only interview in person was with the public transport authority in Region Västra Götaland, Västtrafik, regarding their operations and ambitions.

2.2 Survey

A survey was formulated to understand the willingness and perception as well as the travel behaviour correlated to combined commuting of bicycle and train. The focus was the same as for the report, based of people working or living in Region Västra Götaland. However, it was extended to include the regions of Stockholm and Malmö as well, to make the analysis more general for big city regions in Sweden and to enable more responses.

The survey was developed through brainstorming of desired outcome and with an initial wish to obtain basic information about the respondents' commute. Moreover, answer options were included about reasons for having brought the bicycle or not on board a train before as well as for when cycling or not. These reasons were assumed to be relevant for formulating MM and Nudging measures. The first questions were updated after more literature research and expanded. Approximately 10 people were test objects to help with iterations of the survey and to detect flaws.

The survey was web-based to gain a broad spectrum for the answers, using the online platform Microsoft Office Forms. It was set up in a manner that some questions used the function of *branching*, i.e. redirecting answers based on previous answers. The two branching options were based on location of respondent and whether or not the respondent travels by train regularly when commuting. The first and only cut-off was for those not living nor working (or studying) within one of the three regions. These respondents were redirected to the end of the survey; hence they did not answer any questions. Respondents who reported regular train use were redirected to a few questions related to their travel behaviour. Those who answered that they do not use train regularly were past the questions of travel behaviour and directly to questions regarding preferences and information. The desired amount of preferences was maximum two, to understand which alternatives were more important. However, there were a limitation in the free version of Microsoft Office Forms, where it could not be programmed and hence were the number of choices not technically restricted.

The survey was conducted in Swedish as the intended audience was people living in Sweden. The full survey is presented in Appendix I and II, as both in the original form in Swedish and a translated English version. The survey was put on Facebook, LinkedIn and sent out to employees at Ramboll for the offices in Gothenburg, Stockholm and Malmö. The survey was open for approximately two weeks, providing a total of 608 answers. After the survey was closed the results were gathered in an Excel sheet. The suitable nominal and ordinal answers were used in a binomial regression model to investigate the importance of these variables on the outcome. The total survey was analysed with a more general methodology, later to be matched with relevant technical solutions and soft measures given by the literature research.

2.3 Binomial Logistic Regression Model

In transportation modelling, discrete choice models are based on an individual choosing between a finite number of alternatives, which is referred to as the choice set (de Dios Ortúzar & Willumsen, 2001). There are several types of discrete choice models, where the most common are logit and probit. Within those, the most common types of logit and probit analysis are nested logit, multinomial logit model as well as binomial logit model. The latter is the analysis applied in this report, where the analysis may also be defined as a type of logistic regression.

In a Binary logistic regression is the choice set consisting of one dependent variable with two possible outcomes, as well as several independent variables (de Dios Ortúzar & Willumsen, 2001). These variables could be of nominal, ratio, interval or ordinal character. The independent variables could vary in character while the dependent variable is required to be nominal. The outcome of this type of model is the probability of a random individual within the population to make a certain choice within the set outcome choices. The model is based on individual decision makers choosing between alternatives. These alternatives must be feasible and known to the decision maker. It is assumed that the intention for every individual is to maximise the so-called utility, based on the attributes of the alternatives. Each independent variable contains two or more alternatives, where alternatives in the coming analysis are named parameters.

There are several requirements that the choice set and the model must fulfil (de Dios Ortúzar & Willumsen, 2001). The parameters, in both the independent and the dependent variables, need to be collectively exhaustive alternatives. The alternatives must be mutually exclusive and the maximum of choice parameters within each variable is limited to one. From this, probabilities can be calculated, connected to what choice an individual would make a from a set number of choices. The decision rule for the model is always to maximise the utility of individuals.

The logistic regression is based on the concept of odds, calculated from probability of an event occurrence, P (Rodríguez, 2007). Odds describe the likelihood of events as in Equation 2.1:

$$odds = \frac{P_i}{1-P_i} \tag{2.1}$$

The odds ratio calculated as in Equation 2.1, is often scaled by using the natural logarithmic transformation. That results in a log-odds ratio between - ∞ and 0 for probabilities between (0, 0.5), and between 0 and ∞ for probabilities between (0.5, 1). The scale of the ratio is symmetric around 0 and calculated with Equations 2.2 and 2.3:

$$Y_i = logit(P) = log(\frac{P_i}{1-P_i}) \tag{2.2}$$

$$P_i = logit^{-1}(Y_i) = \frac{e^{Y_i}}{e^{Y_i+1}} \tag{2.3}$$

Probabilities can be obtained from odds and vice versa. The log-odds ratio is estimated by using Equation 2.4:

$$Y_i = logit(P_i) = log\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 x_{1,i} + \cdots + \beta_k x_{k,i} \tag{2.4}$$

The unknown parameters, β_k, are estimated by using the maximum likelihood methods.

2.3.1 Mathematical Framework

The logistic regression can give the probability, P, of an individual selection of a certain choice outcome, Y_i (de Dios Ortúzar & Willumsen, 2001), as explained above. It is the exponential of the choice's so-called utility, U_i, over the sum of the exponentials for all variable's utilities related to the individual. The model is not linear, why the parameters within each variable, $x_{k,i}$, has different coefficients. The probability is, as per explained above, calculated with Equation 2.5. From that, the utility can be calculated with Equation 2.6.

$$P_i = \frac{e^{U_i}}{e^{U_1} + e^{U_2} + \cdots + e^{U_j}} \quad (2.5)$$

Where,

$$U_i = \beta_0 + \beta_1 x_{1,i} + \cdots + \beta_k x_{k,i} \quad (2.6)$$

$x_{k,i}$ = explanatory, independent variables
β_k = coefficients relating to each parameter within every independent variable, x_i

There are only two options for the outcome Y, since the model is of binary character. The utilities are calculated with respect to the reference category, 0. With two possible outcomes, there are only two probabilities where the alternatives are 0 or 1. Hence, Equation 2.7 and 2.8 give:

$$e^{U_0} = 1 \quad (2.7)$$

Consequently,

$$P_1 = \frac{e^{U_1}}{e^{U_1} + e^{U_0}} \quad (2.8)$$

2.3.2 SPSS Software

The software used for the analysis was SPSS where the methods and equations described above are included as features of the programme. The outcome from the programme is the difference in utility from the several variables. The parameters within the variables needed to be so called dummy-coded since they are categorical variables and not continuous on a scale. The model is not linear and a coefficient, β, is produced for each parameter.

One important feature of the programme besides the set-up of the model is the check of accuracy of the model. The statistical significance of individual variables and parameters and of the complete model is presented with various test methods. The programme has the default setting of 95 percent confidence interval for the statistical significance, hence most of the following threshold values are 0.05 for the different tests.

As the first step in binomial regression, SPSS creates a null model. The null model is also labelled as the intercept model or Block 0, which in short creates a model that disregards all the variables and draw only on an intercept to fit the fed in data. Afterwards does SPPS create a new model that includes all variables, called Block 1. For Block 1, SPSS presents tests of significance.

The Omnibus test checks if the model Block 1, containing the variables, is statistically better than the intercept model. The Omnibus test is based of likelihood-ratio of both model iterations, where it performs a chi-square test between the two (ReStore, 2011a). More specifically, the Omnibus test checks the difference between the -2LL, i.e. the log-likelihood multiplied by -2 to convert it into chi-squared distribution (ReStore, 2011b). The lower the -2LL value, the better the model is at predicting the outcome. For the Omnibus test, if the difference of -2LL is significantly reduced for Block 1 compared to Block 0, the new model is significantly better at foreseeing the deviations in the outcome. The presented value should be lower than the threshold value of significance 0.05 to indicate a significantly better model than Block 0 (IBM, n.d.-b).

The Hosmer and Lemeshow tests for goodness of fit, which calculates if the model does a sufficient job of representing the data. The threshold value for the significance (sig.-value) of Hosmer and Lemeshow is 0.05 as for the Omnibus test, but where the model is determined a good fit if the value is exceeding the threshold (IBM, n.d.-c). The Hosmer and Lemeshow test is performed by splitting the sample used for the model into groups based on the predicted probabilities (IBM, n.d.-a). The number of groups, *g*, is usually around 10. The test calculates an average from the predicted probabilities to represent the formed groups. The null hypothesis for the test is that the observed values match the predicted values. The Pearson chi-squared value, usually used to check significance, is calculated as in Equation 2.9.

$$\chi^2 = \sum_{k=1}^{g} \frac{(O_{1k}-E_{1k})^2}{E_{1k}} \tag{2.9}$$

The Hosmer and Lemeshow is then calculated as per Equation 2.10 below (IBM, n.d.-a). The number of the group is defined as *k*. *O* and *E* are the total observed and expected frequency for each group, respectively. The previously explained average predicted probability representing each group is here defined as ξ_k.

$$\chi^2_{HL} = \sum_{k=1}^{g} \frac{(O_{1k}-E_{1k})^2}{E_{1k}(1-\xi_k)} \tag{2.10}$$

The degrees of freedom, df, from the calculation is for binomial regression two less than *g*, i.e. it is based on how many groups the test forms in the initial stages (IBM, n.d.-a). The significance value is thereafter the probability of the chi-square statistic, with df *g*–2, being higher than or equal to the goodness-of-fit from Hosmer and Lemeshow calculation.

The input used for the model in the programme was to label all independent variables as categorical in the settings. The method used for the analysis and model setup was in the first iteration “Enter” which is the default option for binomial logistic regression in SPSS. Furthermore, in order to gain deeper knowledge on the contribution and significance of each variable, the method “Backward: LR” was chosen where LR stands for Log Likelihood. SPSS has a default in the programme where it labels the variables to be statistically significant if the sig.-value is less than 0.05 from the Wald test. The variables with the least contribution to the model is in each step one by one sorted out from the model until only the variables statistically significant to the model remain.

The programme does not solely calculate the coefficients but also multiplies them with each parameter within the variables as explained in Equation 2.11.

$$B_i = \beta_i x_i \tag{2.11}$$

The outcome from SPSS, B_i, are values that may be added together to gain the utility, *U*, seen in Equation 2.12. The model also contains an intercept, i.e. constant, like β_0 in Equation 2.6 above; $B_0 = \beta_0$.

$$U_i = B_0 + B_1 + \cdots + B_i \tag{2.12}$$

Thereafter the probability can be calculated as described in the Section *2.4.1 Mathematical Framework*, with Equation 2.8.

2.3.3 Model Setup

All the questions from the survey, see *Appendix I* and *II*, could not be included in the binomial regression analysis. The questions that only had nominal answer alternatives, i.e. descriptive text answers regarding perception and not actual travel behaviour were excluded from the regression model. The chosen questions were for the group of respondents that had reported regular train use. The dependent variable was chosen to be if the respondent would bring a bicycle on the train *more* if the circumstances were to be improved, with the answer options *Yes* and *No*, resulting in a binomial logit model rather than a multinomial. To enable a statistical binomial logistic regression from the questions that were chosen to be applicable, some modifications had to be made to the data set. Some alternatives were merged like whether the respondent used the train to commute within the big city boundaries or otherwise in the region, see further description below. Others were simplified to be expressed in a way that complied with SPSS. The following alterations were made to the initial data set.

The question about travel mode and distance to and from stations was adapted to fit into SPSS. Since SPSS can only process binary nominal variables or variables that could be ordered it was reorganised to distance longer or shorter than 2 km to and from stations. These distinctions were already made for the travel modes *bicycle* and *car*. The two other options were *walking* and by *public transport*, which for the sake of the model were assumed to be shorter than 2 kilometres and longer than 2 kilometres respectively. Consequently, the model considered distance instead of travel mode.

Furthermore, some parameters were only represented by few respondents and therefore not statistically significant. They were therefore excluded from the statistical model. This type of exclusion was made for the age parameter of *10-19* years as well as the age category of *over 65* years. The other parameter excluded was the option *Other* in the gender variable. The variable of which direction the commute took place was altered as well. The initial parameters from the survey was *Within*, *Outside*, *To* and *From* the main city of the region. This had to be changed into a binary variable as it is nominal and cannot be ordered. These parameters were then consequently grouped into *Within* and *To, From or Outside city*.

The question regarding if the respondent had previously during the last 12 months brought a bicycle on a train was modified to either *Yes* or *No* from different ranges of frequency. This simplification was performed in since the number of people choosing within each range was relatively small in comparison to those who had answered *No*.

Table 2.1 below is presenting the questions from the survey after adapting the answers to fit into SPSS. For comparison to the initial answers, the original survey is presented in Appendix I and II for Swedish and English respectively. Since none of the independent variables had a set range and order within the parameters, they had to be coded to be included in the analysis in SPSS. The parameters within the variables therefore had to be dummy-coded as text cannot be read by SPSS. This is presented in the far-right column in Table 2.1 below named “SPSS, dummy-code”.

Table 2.1 Variables and coding in SPSS.

Question	**Answer**	**SPSS, dummy-code**
Commuting within the city or outside/over city boundaries	Within To, from or outside city	1 2
Frequency of train use per week	< 1 1-2 3-5 > 5	0 1 2 3
Distance from home to access station	< 2km > 2km	1 2
Distance from egress station	< 2km > 2km	1 2
Gender	Woman Man	1 2
Age	20-29 30-39 40-49 50-65	2 3 4 5
If the respondent has taken the bicycle on train the last 12 months	No Yes	0 1
If the respondent would use the bicycle more (depending on their stated reasons)	No Yes	0 1

2.4 Data Analysis

The questions and answers that could not be contained within in the binomial logit model were included in a simple data analysis, together with the other answers as well. Excel was used to present characteristics of certain groups, mainly in connection with the previous binomial model conclusion. These characteristics were used to foremost draw conclusions connected to the Gothenburg area, Region Västra Götaland. In order to make the analysis, the data was sorted and altered where needed, some questions had the option of free text answers and those answers were categorised. The results were presented in charts and diagrams.

The answers were used with an expectation to identify focus areas for soft measures and to understand where the problem within bringing bicycles on board lies. The differences in attitude between the three big city regions were analysed as well as the connection to the binomial model regarding the impact of factors such as age and travel behaviour.

3 Literature study

The following chapter describes the theory of multimodal transport systems and specifically the combination of bicycles on board trains, followed by examples of multimodality used in different locations. Afterwards is information on soft measures, their applications and examples of different types presented.

3.1 Transportation Systems

A system consists of separate components and to grant the function of any system, the components need to interact (Meyer & Miller, 2001). That applies to transportation systems as well, made up by several components, working lucrative when operating together. From the principle of the book *Urban Transportation Planning*, Meyer and Miller (2001) assign five components to the transportation system; *system users*, *transportation modes*, *infrastructure*, *intermodal connections* and *stakeholders*.

The notion of *system users* is important since the individuals' travel behaviour differ depending on the preference of one mode over another based on its utility. Therefore, the *transport mode* is also an important component with different characteristics. A trip with for example public transport is most often assisted by a so-called FMLM (First Mile/Last Mile) mode to complete the door-to-door service. It could for instance be by walking to get from origin to destination and completing the public transportation trip (Holladay, 2002; Meyer & Miller, 2001). The transportation modes in urban areas have varying characteristics and are used depending on the individual desired purpose of the trip, which is presented more thoroughly in Section *3.1.2. Multimodality*.

The *infrastructure* supplies the networks, facilities and necessary mobility services for cities (Meyer & Miller, 2001). The performance in terms of operation is critical to consider, to guarantee adequate levels of accessibility and mobility to travellers. Managing and maintaining the infrastructure are therefore important factors. It is also important with the system interaction and connectivity which should be as high as possible, in order to secure the effectiveness of a transportation system. In other words, it is crucial for an effective transportation system to keep the *intermodal connections* at high levels. Finally, *stakeholders* are also affected by transportation. This include companies, organisations and stores relying on the mobility of employees and customers, as well as those affected by negative impacts from transportation systems such as air pollution, noise and so forth.

3.1.1 Transportation Modes

For private transport, people can use different kinds of transport modes, such as public transportation (rail, bus, tram or maritime), bicycle, walking and private motorised vehicles (passenger cars or motorcycles) (Eltis, 2015). The sustainable modes of transports are mainly considered to be the first three mentioned. The transport modes all have their respective advantages and disadvantages.

Cars offer high accessibility, with a flexible door-to-door service, and speed while being comfortable which is one reason for the high usage (Williams & Brömmelstroet, 2017). According to Holladay (2002) is the more sustainable fundamental mode of transport walking and the mode with the highest mobility while cycling is faster and therefore enabling longer range. For trips up to three kilometres, cycling is most often faster than traveling by car. However, for distances longer than one and five kilometres respectively the car is superior to walking and cycling in speed and therefore also in accessibility (Williams & Brömmelstroet, 2017). Public transport is fixed by its travel routes which means that the accessibility is lower than for other transport modes. To overcome the benefits of car use, one can combine two or more of the sustainable modes, consequently go from uni-modal to multi-modal trips (Kager, Bertolini, & Te Brömmelstroet, 2016).

3.1.2 Multimodality

Multi-modality and inter-modality are concepts where two or more transport modes are used to fulfil the door-to-door service as the uni-modal is insufficient to connect the origin and destination for longer distance trips (Kager et al., 2016). Multi-modality is the term most often used for passenger transport, why the concept is hereafter referred to as such. The concept is the connection between transport modes and suggests that one mode is used for the main part of the trip and the others are so-called access or egress modes. If consisting of three trip segments, the access and egress modes often are FMLM modes such as walking or cycling.

When combining transport modes, the total benefit can be greater than the added benefits of the modes separately and the weaknesses may be avoided. As stated by Dodson, Mees, Stone, & Burke (2011), public transport is most efficient when made with regards to passenger accessibility. Public transport functions best when planned as part of a network to provide multi-destination trips, in contrast to being planned as individual routes to specific destinations.

The previously mentioned components of a transportation system are parts of a multimodal transport system with synergy as a crucial aspect for high effectiveness (Meyer & Miller, 2001). It is central to transport planning to ensure proper component coordination. Among the components are, as stated, the transport modes which can be used differently depending on the intention of the trip. Figure 3.1 below shows the typical speed plotted to the accessibility for different transport modes in comparison to each other. For those who already use the train service would a facilitation of using the bicycle-train system, further explained in the next section, increase the accessibility greatly.

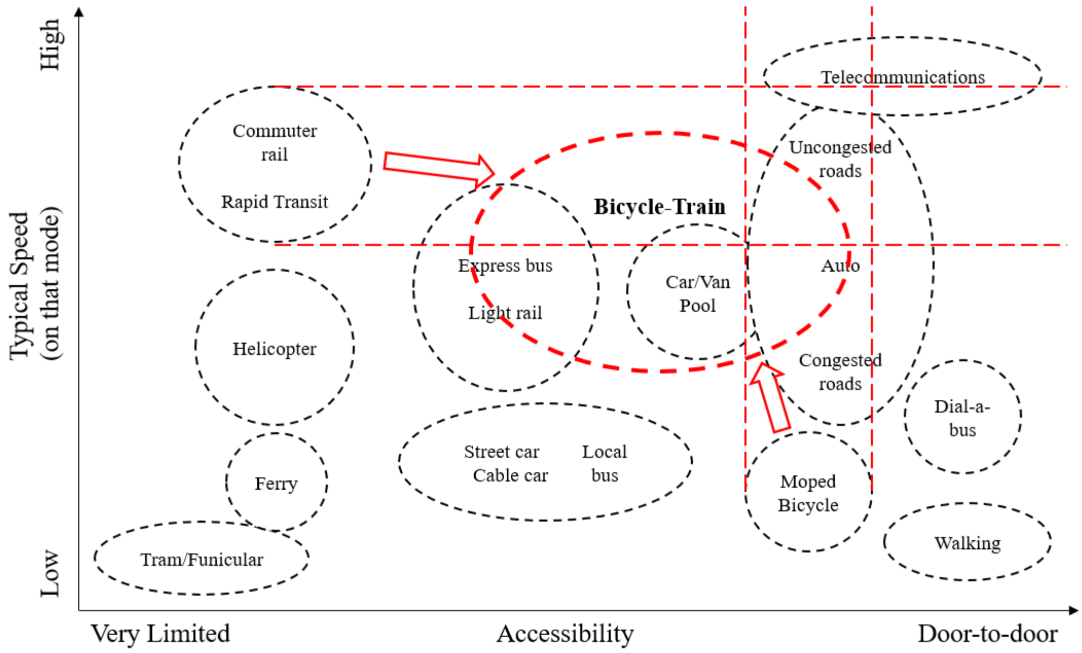


Figure 3.1 *Typical speed versus accessibility for several transport modes. The bicycle-train system in red. Illustration by Lina Sköldberg, inspired by (Kager et al., 2016).*

3.1.2.1 The Bicycle-Train System

From Figure 3.1, some conclusions may be drawn. The combination of bicycle and train improves the door-to-door accessibility of the rail service while increasing the speed and spatial range for the bicycle. Furthermore, the bicycle-train system can exceed the average speed versus accessibility relationship and is possibly both more accessible than other public transportation as well as faster than many other transport modes. The potential for the separate transport modes increases as the geographic coverage area, i.e. catchment area, gets expanded through the combination of bicycle and train. The catchment area for public transportation increases when bicycles are used as FMLM mode compared to walking, with up to three times as long distance measured in a case study in the US (Flamm & Rivasplata, 2014). It was shown that the ability to bring the bicycle on public transport in Philadelphia and San Francisco generally did not enable otherwise impossible trips, but reduced the cost in terms of monetary means, time and/or environmental impacts. However, surveys performed by Kantar Sifo in Sweden, a company specialised on market and opinion surveys, showed that in 2016 would on average 28 percent cycle more if bicycles were allowed on public transport vehicles and specifically 33 percent in Region Västra Götaland (Svensk Cykling, 2016). In 2017 was the total presumed increase 42 percent, a third more than in 2016, on the country average for the same question (Svensk Cykling, 2018).

For trains specifically, combination trips with bicycles can be done in different ways. Nonetheless, to be defined as a bicycle-train system must the three following statements be fulfilled (Kager et al., 2016), further specified from the multi-modality concept.

1. One or more trip segments are made by train, representing the main segment of the total trip.
2. One or more trip segments are made by bicycle and at least one must be connected directly to the train segment.

3. The access and egress must be made by bicycle, walking or public transportation.

The final criterion is set since the purpose of the bicycle-train system is to supply a feasible option to car usage.

The total trip segments are divided in *access*, *transit* and *egress* (Williams & Brömmelstroet, 2017). *Accessing* the departure train station from the origin is often done by foot, bicycle or with public transportation. The advantage of choosing the bicycle is higher accessibility and speed compared to the alternatives. The *transit* segment with train service covers the largest distance of the trip and has the highest speed. The train is used to expand the range compared to only cycling and, in some cases, it is possible to bring a bicycle on the train. From the arrival station, the *egress* segment refers to reaching the trip destination. Similar to the access segment, the egress can be done by foot, bicycle or public transportation. When performed through walking or cycling, the door-to-door service is completed.

For the bicycle-train system to be as effective as possible there are seven conditions stated to be important factors (Küster et al., 2016). *Parking at stations* and *sharing systems* are two of them. The remaining five are applicable to bringing bicycle on board and will be presented here. *Information* regarding bicycles such as the terms and conditions should be displayed clearly as well as provided in timetables and travel planners. It should furthermore be clear where cyclists should be located, both at the platforms and in the train carriages. The *prices of bicycle tickets* should include the whole trip, not per train, and should according to Küster et al. (2016) not be higher than 10 EUR within the national boundaries. International bicycle tickets should not exceed 15 EUR and a proposition is to introduce quantity discount for passengers frequently using the service. Moreover, *ticket reservation* should be possible but not mandatory for a bicycle through all booking platforms and a nearby seat should reservable for a convenient bicycle-train trip.

Additionally, the *accessibility* to and from the platforms and the train is important, where clear signs within three kilometres of a train station for notice, at arrival ways to bring the bicycle to the platform and how to access main cycling routes after egress should be in place (Küster et al., 2016). Ultimately bringing a *bicycle onboard* should be possible on all train services and categories. Opportunity to lock bicycles and charging of electric ones should be possible. A proposed minimum of eight spaces dedicated for bicycles should exist and ramps should be provided if the train carriage floor not is on platform level. According to Küster et al. (2016) is the option to bring the bicycle on board train carriages the only option flexible enough to enable a choice of start and destination of a bicycle trip. Therefore, it is claimed to be a promising investment market for all rail investors.

The European Cyclists Federation (ECF) consists of cycle associations from over 40 countries with the aim to influence policies supporting cycling in order to increase cycling all over Europe. A document on behalf of the ECF (Küster et al., 2016) includes practices to combine cycling with train services. Accordingly, it is stated that the catchment areas of the train services can expand as a result of the integration of bicycles on trains as also identified by Kager et al. (2016), and operators may thereby gain more customers. Simultaneously, the combination is a viable alternative to private motorised vehicles for the door-to-door service (Küster et al., 2016). It is however important to consider the intrusion on other passengers' availability, especially during rush hours when capacity often is maximised. Every cycle passenger covers the space of six standing people according to a study by Mott MacDonald (2008) based on a calculation of average spatial occupation of 0.25 square metre per passenger. The capacity is hence reduced by five standing passengers for every bicycle passenger (Mott Macdonald, 2008). The capacity is not decreased as much if the potential passengers are seated. A common reason for not allowing bicycles on board during rush hours is exactly this, the possible interference with other passengers which need to be accounted for.

An option of enabling the bicycle-train combination while avoiding intrusion on space on board is to invest in good parking facilities and bicycle sharing systems. Sharing systems may be accessed by anyone yet in a city such as Gothenburg (Styr & Ställ, 2019) but there is a lack in smaller towns. The service is most often not present in smaller urban areas as the success of the service often requires a large enough population (Gris Orange Consultant, 2009). There is a recommendation of at least 200,000 inhabitants to implement bicycle sharing systems, even though it has been successful for smaller cities like Drammen, Norway, with a population of 60,000. Nevertheless, the towns in question in Region Västra Götaland, surrounding Gothenburg and providing it with commuters, are most often smaller than Drammen and substantially lower than 200,000 (SCB, 2018). Bicycle sharing systems are therefore not on the agenda for these towns in the present situation and a bicycle can therefore not be used as both access and egress mode with sharing services if living, working or studying other than in Gothenburg. With adequate parking facilities a private bicycle may be used as a FMLM mode and a sharing bicycle for the other trip connected to the train. However, as Gothenburg's sharing system uses stations where one must leave the bicycle in the present situation (Styr & Ställ, 2019), an additional travel mode is often needed to complete the door-to-door service. Hence, the choice of investigating bicycles on board.

3.1.3 Examples for Implementation of Hard Measures

When planning for measures in Sweden, the Swedish Transport Administration practice a concept translated to "*The four-step principle*" (Trafikverket, 2018a). The order in which procurements are evaluated for planning is according to the principle described below.

1. Re-think
2. Optimise
3. Re-build
4. Build new

The concept is used to ensure sustainable resource use and that the measures contribute to a sustainable society. The steps are meant to be considered in this order and the chosen step may be used if the demand cannot be supplied by the previous step(s). The steps may however be combined as it most often gives more effective solutions. The first step, *re-think*, covers measures that affect the demand of different transport modes for instance, such as information and promotion, while the second step, *optimise*, look to make the existing infrastructure more effective through logistics solution for example. *Re-build* covers limited reconstructions such as broadening or implementing

ITS, Intelligent Transport Systems, while *build new* refers to new investments or larger reconstructions such as new lanes or railroad tracks.

Focusing on the second step *optimise* with regard to the combination bicycle and train, parking facilities or bicycle sharing systems may be updated and renovated to ensure decreased bicycle theft and increased mobility (Cerny & Daggers, 2016). However, if the desire in public is to use the bicycle both before and after the train trip segment, a more efficient and effective alternative is to facilitate the possibility to bring a bicycle on board. Before any implementation, several aspects such as local rules and regulations, specific technical solutions, promotion measures and investment cost need to be considered. Regulatory updates are required when new solutions are brought to use, to among other things ensure passenger safety, quality and balanced utilisation of the space potentially shared by bicycles, strollers and wheelchairs. The following section does however focus on the technical solutions.

There are many solutions for bicycle stand measures outside the buses, when looking into buses instead of train as the mode for public transport, like trailers or bicycle stands in the front or on the back of the bus (Cerny & Daggers, 2017). However, Gothenburg is not suited for bicycles on board buses according to M. Albihn (interview April 3, 2019), neither the buses themselves nor the stations. Furthermore, this thesis is focusing on rail, why measures on trains will be presented and therefore technical measures are described as inside the vehicle together.

3.1.3.1 Shared Space

The bicyclists may be directed to shared spaces, either to stow away or the bicycle to be hand held by the cyclist (Cerny & Daggers, 2016). Typically, the bicycles must be stowed in such a way that entrances are not blocked, and easy egress is not affected, especially in case of emergency. If held by hand, the space should for example be designed so that bicyclists are able to be near a post, to avoid falling if emergency stops occur. The advantage is that other passengers can use the same place without any complications when the bicycle use is low. A common contemporary solution is to offer open and shared spaces with foldable seats, but without the possibility to secure bicycles with straps or other devices.

To improve the safety for all passengers, restraining equipment may be used (Cerny & Daggers, 2016). There are several types of stands and devices used on board in different cities. For the case when cycle stands are installed in a mixed storage, they can be placed under foldable seats or in open space shared with other standing passengers. Whereas the safety increases regarding cycle stands with fixation systems, the flexible capacity is decreasing slightly compared to the completely shared spaces. Concerning all potential solutions for shared space, priority can be settled (e.g. for bicycles or wheelchairs) or the concept first comes first served may be exercised. If priority is practised, those with lower priority may have to exit the vehicle if a higher priority passenger enters. Depending on the alignment and focus of the local authorities, the priority regulation alters between different cities and regions.

An example of positive evidence of improving the possibility for bicycles on board trains, according to Holladay (2002) did the company Caltrain in California measure a 1,400percent increase of bicycles brought over a three-year period. From the initial 100 bicycles per day was almost 2,000 trips made with bicycles, as a result of reforming to an upgrade in bicycle capacity of 24 places; four bicycles replaced four seats located in six places along some of their train sets. The solution is presented to the left in Figure 3.2. Examples of further solutions that may be placed in shared space are presented to the right in Figures 3.2 and in Figure 3.3.

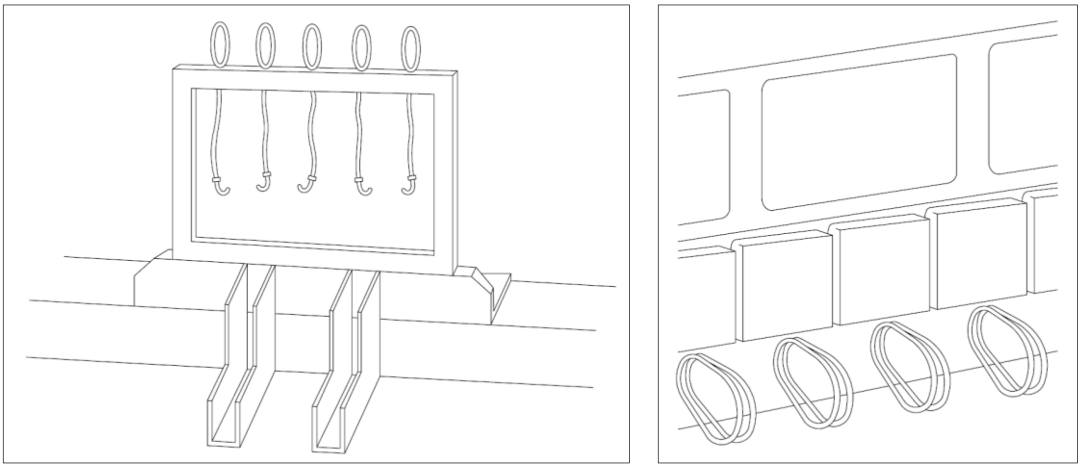


Figure 3.2 To the left, the Caltrain solution in California, described in Holladay (2002). To the right, shared space with fodable seats as in Cerny & Daggers (2016). Illustrations by Lina Sköldberg.

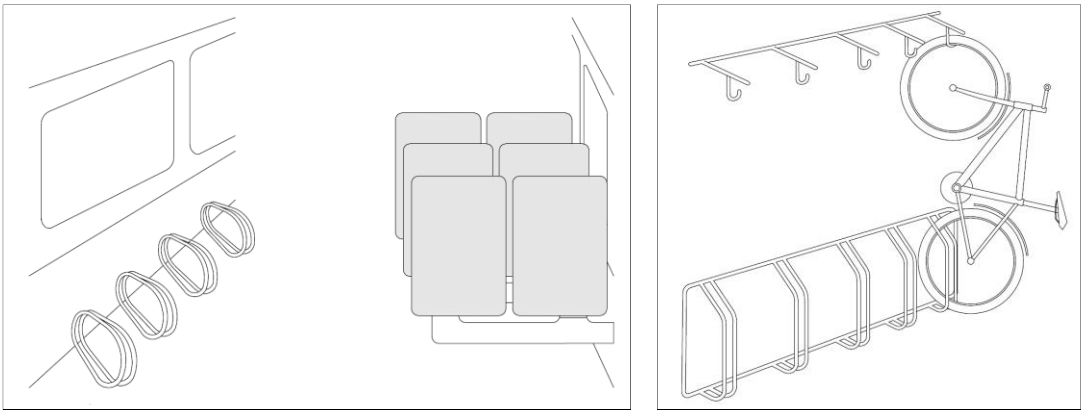


Figure 3.3 To the left, shared space with stands to the left and seats to the right of a carriage. To the right, stands with hooks inspired by Cerny & Daggers (2016) and Envall et al. (2011). Illustrations by Lina Sköldberg.

3.1.3.2 Dedicated Bicycle Storage

A bicycle number limitation together with dedicated places could be implemented to further control the safety, with information easily and clearly displayed (Cerny & Daggers, 2016). These spaces may or may not be used by others if space permits and folding seats may be present, but where bicycles have priority. Consequently, the bicycle storage stands or units can be designed as in the previous section (Figure 3.2 and 3.3), but the rules regarding priority alter. A further option is to introduce specific bicycle train-carriages with large open spaces and many bicycle stands, for example such as can be seen to the left in Figure 3.3.

3.1.3.3 Platform Access

As previously mentioned concerning conditions for an effective bicycle-train system (Küster et al., 2016), a key aspect to consider which often is decisive for if people bring the bicycle or not is the accessibility to the platform (Cerny & Daggers, 2016). Mainly it concerns making staircases bicycle friendly, if bicycles are not allowed in escalators, through installation of a conveyor or a ramp for the bicycle in the pedestrian stairway as illustrated in Figure 3.4. According to Küster et al. (2016) should elevators be the standard solution to facilitate access to the platform for everyone with bicycle. Furthermore, through minimising the height difference as well as the distance between the train and the platform the access and egress is further facilitated, while also wheelchairs and strollers benefit from this measure (Cerny & Daggers, 2016).

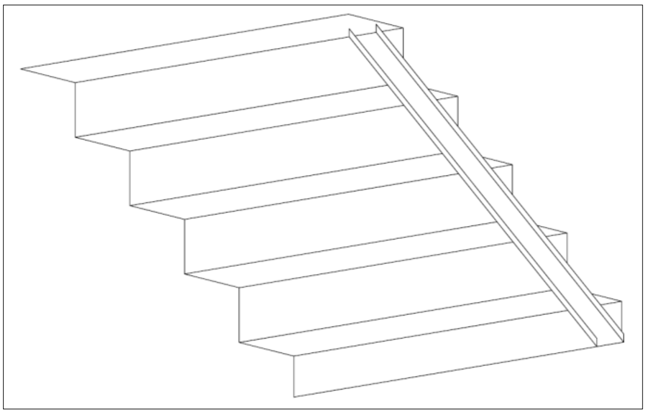


Figure 3.4 Illustration of a bicycle ramp in a stairway by Lina Sköldberg.

3.2 Current Situation in Different Cities

The general goal for transport policy in Sweden is from the government expressed as giving everyone a long-term accessibility with good quality and usability through the function and structure of the transport system (Regeringen, 2009). A study performed for the Swedish Transport Administration in 2009 (Envall, Backelin, & Koucky, 2011) showed that the highest reason for carrying bicycles on board the train was to transport it to the place of work or study, why this service is in line with the Swedish transport goals.

A recent regulatory development for the topic of this study, namely the right to carry a bicycle on all kinds of trains, was revealed through a legislative proposition from the European Parliament in 2018; "*Rail passengers' rights and obligations*" (European Parliament, 2018). According to the proposal must new and refurbished trains provide at least 8 designated spaces, which is in line with the conditions from ECF that should be in place for an effective bicycle-train system presented in Section *3.1.2.1 The Bicycle-train System* (Küster et al., 2016). The related texts on the EU proposition is presented in Appendix IV.

Regulations must be considered due to possible contrarious interests between benefits for the society and for the train operators in question (Envall et al., 2011). The short-term financial profits of passenger seating may be more beneficial than space dedicated for bicycle storage without the possibility to be used by others for operators, especially regarding longer trips where a seat is expected. However, there are indications from other countries suggesting that cyclist have high a willingness to pay for carrying the bicycle on board a longer train trip. The societal benefits from the bicycle-train system could in a broader perspective outbalance the monetary loss for single operators, why regulations are developed. A general solution that possibly could be implemented straightforward before regulations such as the proposition from the European Parliament (2018) come into force, is to allow bicycles on board trains with low floor outside of rush hours (Envall et al., 2011).

3.2.1 Sweden

The Swedish market for trains is not set under many regulations regarding who has the right of use but is the most open market in Europe for rail traffic (both for freight and passenger traffic). Therefore, there are several operators on the regional and national markets in Sweden. The different operators are not dependent on each other and therefore have different rules and ticketing systems. Travelling on regional rail traffic has increased significantly during the last 25 year to 3 times the initial size (Trafikverket, 2015).

The train and railway system differ over the country, both in extent and offered kilometres. One way to measure this is by number of train-kilometres offered per inhabitant. It is vastly different between regions in Sweden, where numbers from 2013 shows that Västra Götaland offers just over five kilometres per inhabitant, which is low in comparison to for example Jämtland that exceeds 40 kilometres per inhabitant (VGR, 2016). The two other big city regions in Sweden, Skåne and Stockholm, has just over 15 kilometres per inhabitant respectively. The national average is just over ten kilometres per inhabitant, double the amount for that of Västra Götaland (VGR, 2016).

In terms of cycling, the bicycle culture and usage in Sweden is yearly evaluated through a national bicycle account (Trafikverket, 2017). It highlights several factors that all have an impact on the choice to cycle or not. These factors vary from the importance of having good infrastructure that is maintained thoroughly, to the geographical aspects of length of trip to topographical issues. It also evaluates two points of importance for the notion of multimodality. The first factor of multimodality is individual aspects of for example health, security and preferences. The second factor of multimodality is the last factor of importance called "Full-trip perspective" which is connected to the door-to-door principle explained in previous chapters, that the bicycle trip should work in combination with other modes of transport. The bicycle account also emphasises the importance of satisfactory bicycle parking possibilities in connection to the public transport stations and bicycle sharing system. The bicycle account did however also mention bicycles on trains and that the possibility should be improved in the future (Trafikverket, 2017). The national bicycle account furthermore mentions the Swedish law (Sveriges Riksdag, 2015) "*Om kollektivtrafikresenärers rättigheter*", which accounts for the rights for people using public transport. It states that the party responsible for the public transport should provide information about the possibility to bring bicycles and the terms for that.

The Swedish government issued a national bicycle strategy in 2017 stating actions to be taken, in an attempt to increase the bicycle share in Sweden the Swedish government. (Mattsson et al., 2016). It specifies political goals for safe cycling and mentions for example bicycles as a way of tackling congestion in urban areas since it is more space efficient. The strategy also highlights the "Full-trip perspective" with a focus on creating possibilities to expand and introduce bicycle parking spaces and service stations connected to public transport.

The combination of trains and bicycles could also be an option for tourism or recreational activities, besides being included in daily commuting (Mattsson et al., 2016). Cycle tourism has a big potential in Sweden, and it could be amplified if the possibility of carrying bicycles on trains improves. The possibility is not only for citizens of Sweden, but it could be a selling point to foreign tourists as well. A study was made documenting how many foreign tourists that have used any type of bicycles as an activity during their visit to Sweden, specified by which region the biking occurred in (Skåne Region, 2016). The numbers are from 2015 and represents number of foreign visitors that have performed cycling or mountain biking as an activity during their visit to Sweden. A comparison from around the three big city regions in Sweden show that southern Sweden and Malmö have around 275,000 who stated cycling as an activity, western Sweden and Gothenburg showed around 150,000 while Stockholm had around 250,000.

3.2.1.1 Region Västra Götaland

The public transport in the region through Västtrafik is decided and controlled by the region government of "Västra Götalandsregionen, VGR", i.e. Region Västra Götaland. They have presented a strategy "*Trafikförsörjningsprogram*" which includes goals and aspirations regarding the overall traffic between 2017-2020. It covers the aspect of enhancing the sustainable door-to-door communications, e.g. through combinations of several transport modes.

There are 5 regional commuting hubs in the connected urban area; Göteborg–Mölndal–Partille, Borås, Trollhättan–Vänersborg, Uddevalla, and Skövde (VGR, 2016) which among other communities can be seen in Figure 3.5. These hubs are given particularly high priority when regarding public transport planning in Region Västra Götaland. According to Statistics Sweden (SCB, 2018), the total number of commuters to and from Gothenburg amounts to roughly 175,000 people. The share of commuters that travel in to Gothenburg are as expected larger, 120,000 people, and 54,000 are commuting from Gothenburg to other municipalities within the region. Commuting with high demands in the vastly trafficked hours implies high capacity requirements during a short period of time of the day (Kollektivtrafiksekretariatet, 2013). The numbers of commuters do however not include people commuting for other reasons than daily work such as school implying that an even higher capacity is needed for the total amount of travellers. The presented numbers of commuters does not specify the modal choice for the commuters, yet VGR states that the biggest increase within public transport has been within the regional train transport, which has more than doubled within the last decade (VGR, 2016).

The public transport system in Gothenburg is run by Västtrafik and it consists of buses, trams, trains and ferries. The trains, the focal point of the public transport for this thesis, run by Västtrafik goes under the name "Västtåg". Västtåg allows bicycles on board if space permits, i.e. there is no guaranteed space, for no cost (Västtrafik, n.d.). M. Albihn (interview April 3, 2019) explained that the shared spaces are shared with wheelchairs which have priority and strollers, where the spaces require cycling passengers to fasten their bicycles

The potential of public transport is presented through Figure 3.5 below with difference in travel time for bus compared to car, bus-car, and train compared to car, train-car (VGR, 2017). The train-car is presented with dashed lines, where the green colour represents gained time from travelling by public transport trains compared to with car while red and yellow are degrees of lost time. From this is could be interpreted that there are several directions that would favour commuting by train, for example Älvängen, Alingsås and Lerum, while other directions have worse train connections, an example being Borås.

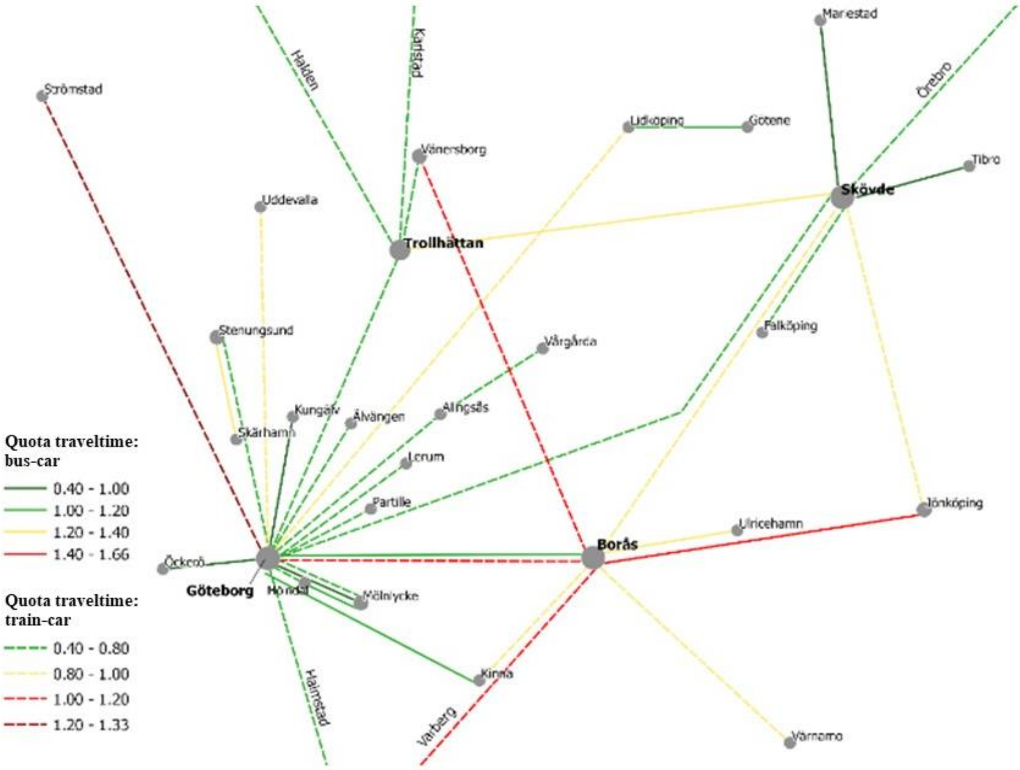


Figure 3.5 Traveltime-quota difference with commuting modes, adapted from VGR (2017).

To improve the time relationships, more departures could be implemented. However, the train infrastructure in Region Västra Götaland is limited, which means there is not a large space for extra train departures in the schedule (Trafikverket, 2018b). The following figures are from 2017, presenting how the capacity of the railway system around Gothenburg was used up, where green represents "small limitations" and red "large limitations". Figure 3.6 presents the average capacity over the full day to the left and the maximum 2 hours of the day to the right. This means that the train traffic is approaching the capacity in several directions around Gothenburg.

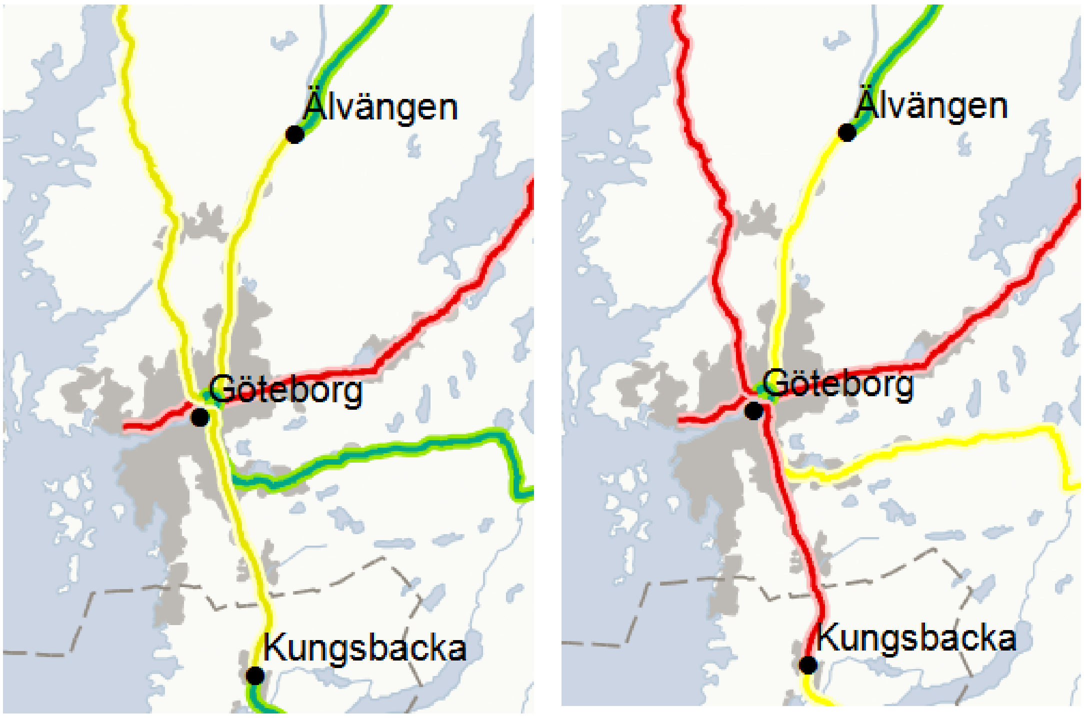


Figure 3.6 *To the left, full day capacity of the railway. To the right, railway capacity of the peak two hours (Trafikverket, 2018b).*

Apart from focusing on public transport, VGR does as mentioned in the beginning of this section, have a strategy to increase accessibility through door-to-door perspective which may include bicycles in many cases. VGR has a strategy that focuses on increasing the modal share for bicycles within the region and to make bicycle into a priority mode in all societal planning at national, regional and municipal level. In the strategy it is stated that bicycle paths which improve the security and accessibility to and from a public transport node is of higher priority. The strategy describes that the region is working towards better possibilities to bring bicycles on board public transport through combined mobility and that the designated space for bicycles on board the trains is improving (VGR, 2015).

Questions were sent to responsible people from VGR to clarify details further. From S. Persson (personal communication February 28, 2019) it was explained that VGR has a network called "Hållbart resande väst", i.e. "Sustainable travelling west". The network works toward getting people to choose sustainable travel modes and to encourage better travel habits, including bicycles. One Mobility Management measure, the concept is more thoroughly explained in Section *3.3 Soft Measures*, that the region is using for combined bicycle and public transport within this network is "*Buss Ohoj*!". It is specified for folding bicycles, where 20 participants are chosen at a time to borrow a folding bicycle for three months to inspire the participants and other people to cycle before and after a public transportation trip. The participants are encouraged to share experiences on social media and are required to send updates on their experiences to the project team throughout the project time (VGR, n.d.).

An interview was conducted in Västtrafik's office in Gothenburg with Marie and Kerstin who both work with the question of combined mobility in the organisation. From M. Albihn (interview, April 3, 2019) it was explained that a rather recent measure to enhance the possibilities of carrying bicycles on board was implemented in 2018, 7th of January, when the ticket price for bicycles was removed. Since then, there has not been any follow-up within the organisation to evaluate the possible increase of bicycles after the measure. However, an investigation is planned for the employees on the trains on their perceived increase as well as their perception on if travellers often are rejected due to lack of space.

Since no information was found about the capacity of the trains owned by Västtrafik, the matter was discussed in the interview. M. Albihn (interview, April 3, 2019) stated that the capacity is between 2-6 places for bicycles depending on the train version. The priority of bicycles in the shared spaces for bicycles, wheelchairs and strollers was defined. The employees have a set priority order in that wheelchairs are of highest priority for the shared spaces over strollers and bicycles which have the same priority. This means in theory that the lower prioritised passengers, with bicycles and strollers, can be dismissed from the train over the higher priority passengers in wheelchair.

M. Albihn (interview, April 3, 2019) stated that Västtrafik currently have high ambitions to expand the combined commuting. They have a planned, coming survey and investigation regarding their customers' attitude on combined commuting. Options that was mentioned was for example including bicycle in the travel planner and real-time signs. The political pressure regarding options for bicycles are high but Västtrafik are not sure that this also implies to their customer-base which ultimately decides the supply.

The new trains that are under procurement and set to be put into operation around the year 2021. These trains will have a capacity of 6 bicycle spaces in a shared space, i.e. the same as the current situation. Hence, these trains will not fulfil the new proposition of 8 places from the European Union (2018). According M. Albihn (interview, April 3, 2019), procurements take a long time and renovations of trains are tricky and expensive. Furthermore, the EU legislative proposal proposing 8 dedicated spaces for bicycles for all new and renovated trains, was stated to be dealt with if and when it has been officially determined.

3.2.1.2 Region Stockholm

In Stockholm, the bicycle traffic is steadily increasing and has a goal that the modal share for bicycles should be at least 15 percent during rush hour by 2030 (Stockholm stad, 2015). The inhabitants of Stockholm do in general accept 30 minutes of cycling one way as a daily commute according to travel behaviour investigations. As of 2015, around 80 percent of the population of Stockholm had 30 minutes or less by bicycle to their workplace. Because of the heavy traffic in the central of Stockholm during rush hours it is stated that bicycle is faster than a car for all journeys within 15 kilometres from the central station (Stockholm stad, 2015). This results in that the average cyclist in Stockholm have a relatively long work commute of around 9 kilometres one way in comparison to the national average which is around 4 kilometres (Trafikverket, 2014).

The company in charge of public transport in Stockholm is called SL, "Storstockholms Lokaltrafik", owned by Region Stockholm. SL allows bicycles on the commuter trains, "Pendeltåget", as well as on Saltsjöbanan with restrictions. Bicycles are completely banned from the metro system and the rest of the trains and buses included in the SL-system (except for foldable bicycles that counts as luggage) (SL, 2019). The restrictions for the trains where bicycles are allowed are that no bicycles can enter or exit the train at the two stations of: *Stockholm city* and *Arlanda*. There are further restrictions in place for rush hours, i.e. weekdays between 6:00-9:00 in the morning and 15:00-18:00 in the afternoon, where only certain commuter trains allow bicycles. All trains which allow bicycles do so if space permits, i.e. there are no guaranteed places for bicycles on the trains. As far as accessibility goes, bicycles are not allowed in the stairs at any station but are referred to the elevators where necessary and no cycling on platforms is allowed (SL, 2019).

The regional bicycle plan for Region Stockholm from 2014 states that the best choice of action to increase multimodality or combined commuting for the city's commuters in the future is to improve the bicycle parking infrastructure around public transport stations. Region Stockholm also emphasises the importance of shared cycling systems. The plan mentions that the opportunities of a more extensive system should be investigated regarding bicycles on trains. It stresses that the main factors affecting the decision of allowing bicycles or not on public transport are capacity issues and the security of the other passengers (Trafikverket, 2014).

The train infrastructure in the region is limited, hence an analysis of capacity is of importance to see if there is room for additional train departures in the schedule. The following figure from 2017 presents how the capacity of the railway system around the Stockholm region is used up, where green is "small limitations" and red "large limitations", same as in the case of Gothenburg as previously mentioned. Figure 3.7 shows average capacity during the day to the left while to the right is the capacity during the maximum 2 hours of the day presented. The figure indicates that there is room for more train departures in the region for longer distance commuting. However, more commonly used for shorter distance commuting within the city of Stockholm is the metro (Trafikverket, 2018b). The metro system is not a part of the national rail lines and therefore not included in the capacity analysis.

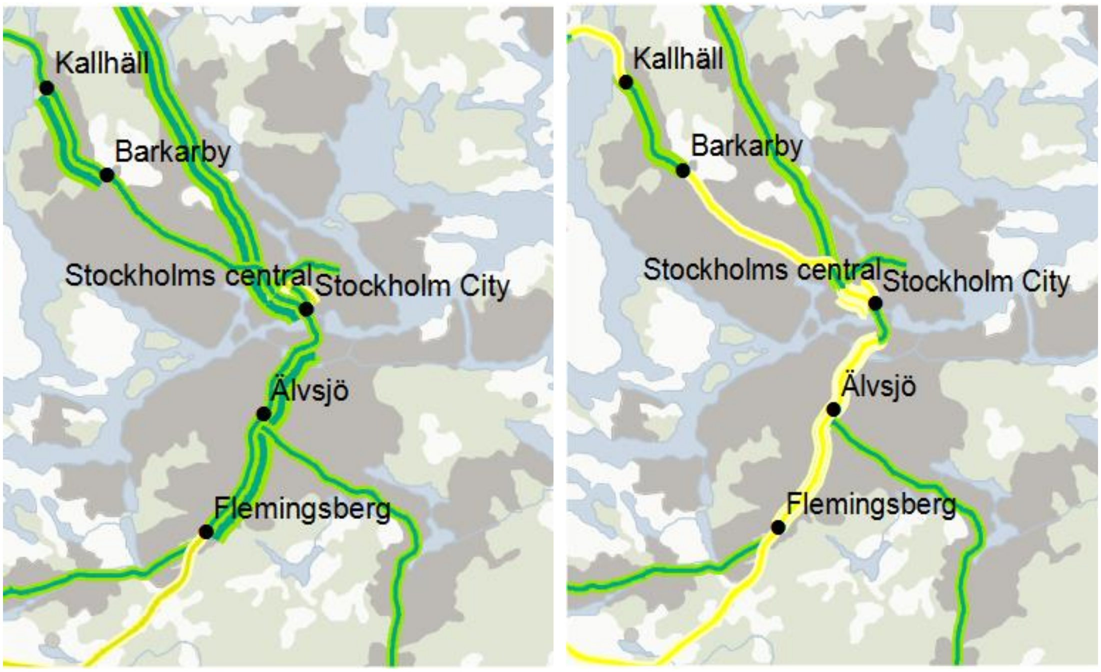


Figure 3.7 *To the left, full day capacity of the railway. To the right, railway capacity of the peak two hours (Trafikverket, 2018b).*

Questions were sent to responsible people from Region Stockholm to clarify details further. I. Stjärnström (personal communication, March 8, 2019) explained that their perception is that the EU regulation does not directly affect the commuter trains as there are no planned requirements or renovations. Furthermore, there are no current plans to change the rules for bicycle use in stations, however it is mentioned that the region might be able to look it over if the proposed EU regulation is officially established.

I. Stjärnström (personal communication, March 8, 2019) informed that they do not have any statistics regarding usage of bicycles on trains as there are no tickets for bicycles. It is difficult to count the number of bicycles on the trains by other means than tickets. Currently there are no set plans for expanding the possibilities for bicycles on board, but I. Stjärnström does not reject the possibility for the future. Region Stockholm's main focus has been to create parking around node points in the transit system. They are also investigating the possibility of shared bicycle system.

I. Stjärnström presented investigations that had been performed regarding accessibility within the subway system of Stockholm (personal communication, March 8, 2019). The study presented problem areas with the regulations set in 2013 when the investigation was performed. The current regulation demands that bicycles are to be brought on the elevators, however there were reports of people not following rules and several accounts of accidents with bicycles on escalators. The security problems with bringing bicycles to underground stations and on board trains are related to bicycles falling and blocking emergency exits. Furthermore, it could be related to bicycles falling onto the rails within a subway system that might cause short-circuit and consequently a fire hazard. Several improvements were presented as solutions to the security problems. Among those were to ban cycling on the platforms and to put up walls between platform and rail. Furthermore, to limit the number of bicycles allowed on each carriage, special carriages for bicycles were implemented to decrease delays.

The investigation concludes that improving the possibilities for bicycles on trains would not affect commuting behaviour largely but only increase the flexibility for a small group of commuters, which in addition already have the permission of carrying folding bicycles (I. Stjärnström, personal communication, March 8, 2019). The investigation contacted responsible people for security in Amsterdam's and Copenhagen's subway system for an exchange of experiences. The experience from the Amsterdam stated that bicycles in shared spaces hinder movement and therefore slow the process of entering and exiting the train. This consequently affects the time spent at the stations and could affect time schedules. The security aspect regarding emergency exits was also mentioned. In conclusion it is not recommended by Amsterdam to allow bicycles in the subway system. The experience from Copenhagen states that they have not had issued with accidents in stations while allowing bicycles on escalators. The recommendation is that bicycles should be allowed under regulations since it allows more flexible trips.

3.2.1.3 Region Skåne: Malmö

Malmö with its geographical proximity to Copenhagen and Denmark is often regarded as one of the most bicycle friendly cities in Sweden. The modal share for bicycle has increased with 65percent in the recent years at the same time as the population only increased by 24percent (Malmö stad, 2017). Train travellers has increased even more than bicyclists in the same timespan (Malmö stad, 2016).

The public transport in and around Malmö and the Region of Skåne is mostly operated by the company "Skånetrafiken". Nevertheless, there are several train operators within the region. There are Pågatåg and Öresundståg, both of which is governed by Skånetrafiken. Krösatågen operates between Skåne, Småland and Halland and it operates in the northern part of Region Skåne (Skånetrafiken, n.d.-b). All these operators allow bicycles on their trains with varying capacity, and all of the operators require a separate ticket for the bicycle. The different operators have different capacities per train set as presented in Figure 3.8 below.

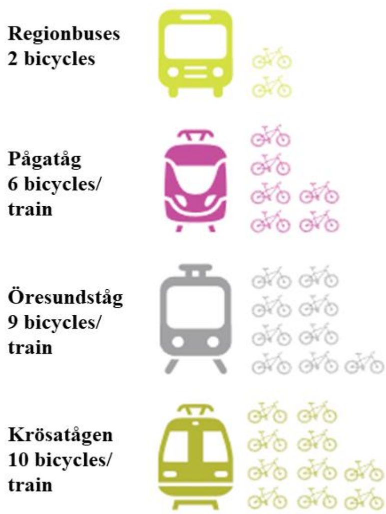


Figure 3.8 Number of bicycles allowed on trains in region Skåne, adapted from Skånetrafiken (2019).

The Region of Skåne as well as the City of Malmö is working on increasing the modal shares of the more sustainable alternatives of transport, i.e. including all modes other than cars in urban areas. The region of Skåne has expressed the will to expand the opportunities of bicycles on trains. In the bicycle strategy for Region Skåne it is expressed that the region should work in a manner to allow more bicycles on trains in future procurements (Skåne Region, 2016). One measure that has been implemented in Skåne to encourage the combined use of bicycles and public transport was to include bicycle combinations as an option in their online travel planner. The travel planner is described in detail in Section 3.3.4.2 *Travel Planner – Website Information – Apps (ICT).*

The train infrastructure in the region is limited which means there is not a large space for extra train departures in the schedule. The following figures are from 2017, presenting how the capacity of the railway system around Malmö and Region Skåne is used up, where green is "small limitations" and red "large limitations", same as in the case of the previously mentioned cities. Figure 3.9 presents to the left the average capacity during the day while to the right is during the maximum 2 hours. According to this, there is still room for more traffic on several stretches around Malmö (Trafikverket, 2018b).

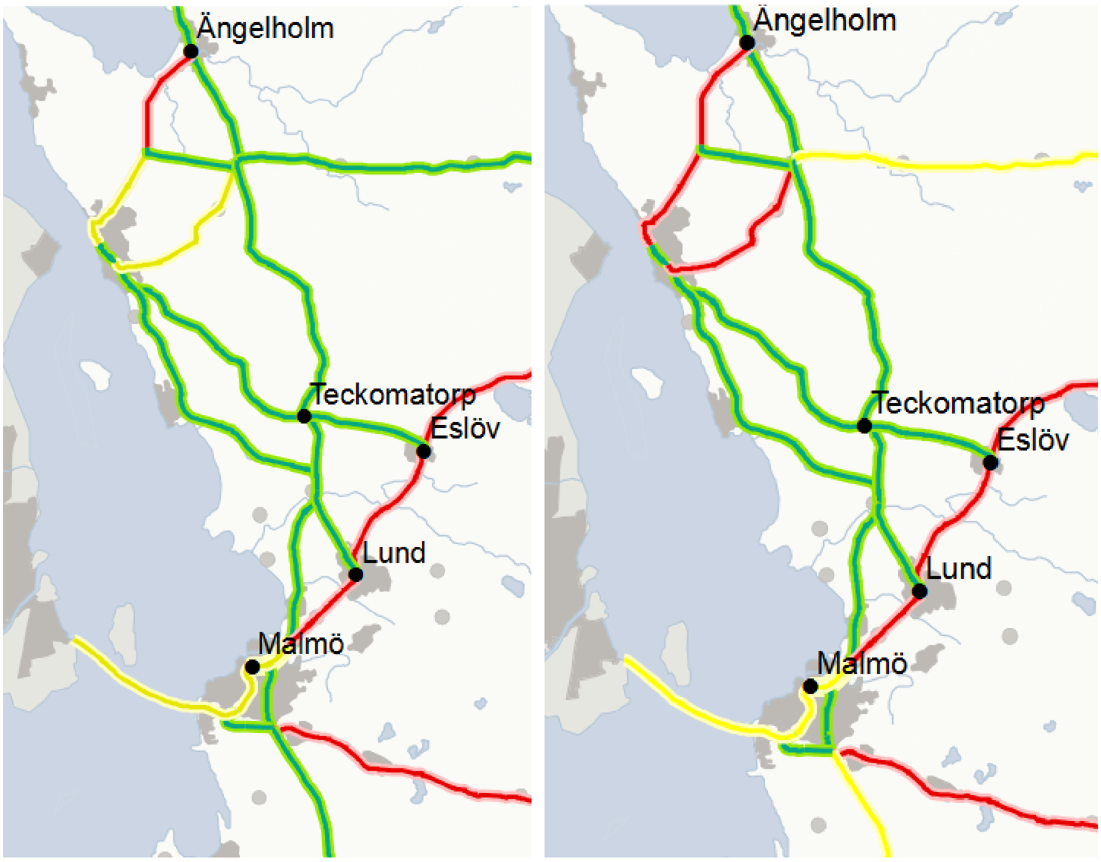


Figure 3.9 To the left, full day capacity of the railway. To the right, railway capacity of the peak two hours (Trafikverket, 2018b).

3.2.2 The Netherlands: Amsterdam

The Netherlands being a relatively small country, has a more symbiotic train system than that of Sweden meaning that they have one ticketing system and that the train runs on a national level instead as opposed to a regional level. The main train operator is NS, which stands for Nederlandse Spoorwegen. The rules presented in this section is covering the trains operated by NS. However, there are several other operators in various parts of the country, e.g. Arriva, Breng, Syntus, Connexxion and Veolia. For these operators the rules might differ slightly, while still all operating organically within the same ticketing system (NS, 2015).

The cycling community in the Netherlands is vast, and the country is known for the high modal share of bicycles. The percentage of trips taken by bicycle nationwide is around 30 percent (Government of the Netherlands, n.d.). Simultaneously, the share of people using bicycles as a feeder mode to the access train stations is just under 50 percent, and just under 15 percent as the travel mode when leaving the egress station (Kager et al., 2016). A part of those, some are using NS' own solution to the multimodality of bicycles and train; the door-to-door service through OV-fiets, NS' own bicycle rental system (NS, n.d.-d). The sharing system has around 300 locations at stations and the usage is limited to be used only by those who have a permanent NS card, i.e. not a tourist card.

Bicycles are allowed on the trains through NS, although a ticket for the bicycle is necessary. The ticket is not exclusively for one train but a general ticket for the time period that the ticket was bought for. Bicycles are allowed on board trains outside of the predefined rush hours of 06:40-09:00 and 16:00-18:30, for most of the year. The exception being that bicycles are allowed at all times during weekends and the summer months July and August. Foldable bicycles are allowed at all hours of the day granted that they are folded during the train journey. There are restrictions regarding placement of bicycles, being referred to specific carriages with mostly foldable chairs. It is not possible to guarantee a spot on the train in these spaces, however do bicycles have priority in the specified places over for example luggage (NS, n.d.-b, n.d.-a).

The capacity of the current train sets is described to be 4 bicycles, i.e. under the recent EU proposition (European Parliament, 2018). However, there are plans for capacity of 12-16 bicycles for the new train sets that are replacing the old in 2023 (NS, n.d.-c). Apart from in carriages, there are bicycle storage units in all stations if the bicycle not is to be brought by any reason.

3.2.3 Denmark: Copenhagen

Cycling is one of the largest modes of transport when regarding modal shares in Denmark and more specifically in the city of Copenhagen. 28 percent of the overall trips in Copenhagen are completed with bicycle and the bicycle share is 43 percent when only considering trips to and from work or studying according to the City of Copenhagen (2017). The city enables and encourages cycling through consistently creating better and safer spaces for cyclists. Another special measure that the city has taken to encourage cycling is the app "I Bike CPH" which assists in finding a cycling route based on time and scenery (City of Copenhagen, 2016).

Bicycles are allowed on multiple of the different modes of public transport in Copenhagen. Bicycles are allowed on the commuting trains, S-trains, that run from the suburbs into the city of Copenhagen for no charge (Visitcopenhagen, n.d.). There is one restriction though, that one of the central stations, Norreport station, does not allow bicycles through the station during weekday peak hours (07:00-08:30 and 15:30-17:00).

In an article by the Danish cyclist's confederation written by Bredal (2012) it is explained that the S-trains introduced free bicycle tickets in 2010, and since then the number of bicycles brought on the train has increased significantly. The number of bicycles on trains have increased from around two million from before it was made free of charge until to around seven million bicycles, which translates to more than a tripled amount. In 2019, the reported number of bicycles on the S-train were showed to be an even higher amount with the total number of bicycle count of around ten million during a year (DSB, n.d.-a). The article (Af Frits Bredal, 2012) states that the initiative has increased the number of journeys not only for cyclists but overall as well. Furthermore, it states that around 25 percent of passengers solely use the train because bicycles are allowed for free. Initially, the train sets were made up of train carriages with multiple use spaces that were shared between wheelchairs, strollers and bicycles. However, new carriages were implemented around 2014 in the middle of the train with large open spaces and bicycle stands.

DSB has implemented several measures to simplify the situation on the platform when several bicycles are entering and exiting the train. Firstly, there are marked bicycle symbols on the platform floor where the bicycle carriage will stop. Secondly, there are marked doors for entering and exiting, respectively, at separate sides of the carriages to avoid collisions and to make it more efficient (DSB, n.d.-b).

Within the city of Copenhagen, the metro runs that also allows bicycles on board. However, the rules differ from the S-trains. Bicycles require separate tickets, and they are banned on weekdays during rush hours (07:30-09:00 and 15:30-17:30), apart from the summer months between June and August when there are no time restrictions in place. Bicycles are to be placed in the middle of the train (Metro, n.d.).

Questions were sent to responsible people from Metro Denmark to clarify details further. Figure 3.10 shows the distribution of bicycle tickets sold over 24 hours, differentiating between weekdays and weekend. The difference may partially be because of the restrictions on weekdays but possibly also because of different habits during weekends.

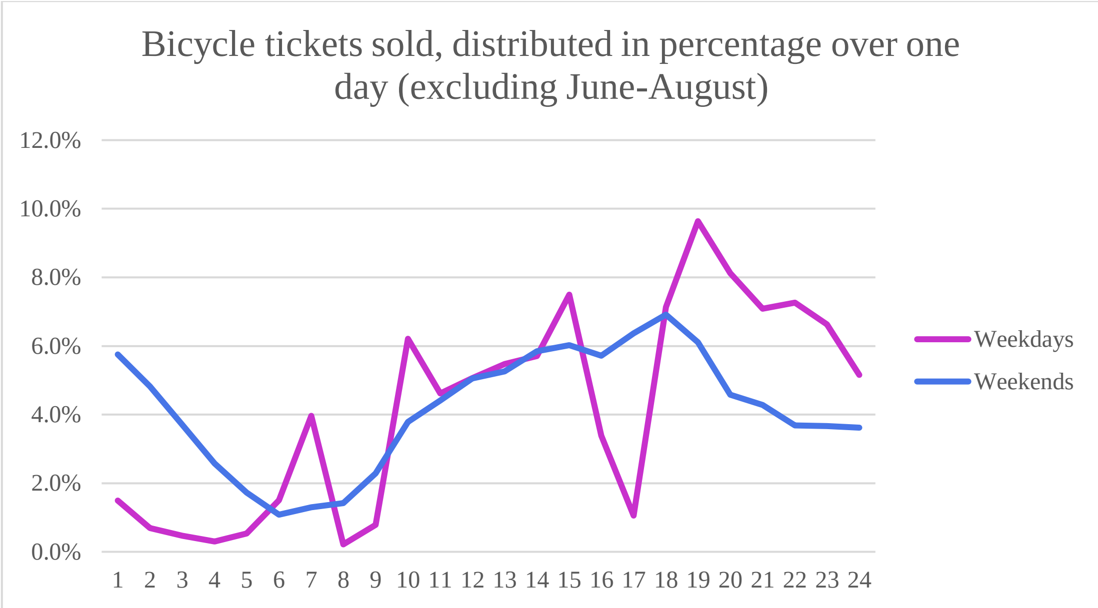


Figure 3.10 Bicycle tickets sold throughout the year over the hours of the day in the Copenhagen Metro. Data from S. Vadt Vejlebo (personal communication, March 4, 2019).

According to S. Vadt Vejlebo at Metro Denmark (personal communication, March 4, 2019), the rush hour restrictions were implemented to maximise the number of passengers on the trains. Further on it is stated that they count on one bicycle to occupy the same space as five people. The accessibility to the station is preferably done via the elevators, a choice made from a safety perspective, where there are one or two elevators in each station reaching the platform.

Some buses also allow bicycles on board in Copenhagen. However, there are space issues as the designated space is the same as for instance for strollers. Bicycles also require separate tickets. Outside of the city on the regional trains run by DSB, bicycles are almost in all instances allowed on the trains, yet with varying rules. Some trains allow bicycles for free and some require tickets. These tickets vary from only general ticket to booking a specific space for your bicycle (DSB, n.d.-c).

3.2.4 Previous Survey for the Swedish Transport Administration

In 2008, a study was performed in the south of Sweden by the Swedish Transport Administration (then National Railway Administration) (Envall et al., 2011). Data was collected through a survey from passengers as well as employees on board trains about the possibility to carry bicycles on trains in Region Skåne. There was a desire to understand why passengers carry their bicycle onboard and the attitude of the other passengers and the employees. The results showed that the opportunity to bring the bicycle on the train was not widely used, roughly 20 percent had brought their bicycle once or more the past year, which according to the authors of the study meant that only limited space was needed for bicycles on board. It was concluded that by carrying the bicycle on the train, mobility freedom increased and the travel times shortened, especially beneficial for those not owning a car or having a driving license.

The study also showed that, in contrary to initial beliefs at the time, that only one percent of other passengers saw the bicycles as a problem and that they had a more negative attitude towards other passengers speaking or uncomfortable temperatures (Envall et al., 2011). The conclusion of willingness to pay for the service was drawn from examples of other cities in Europe offering the possibility, where the willingness to pay was higher for long distance trains and local trips often did not have an extra fee for bicycles. Eliminating uncertainties of space issues and having discounts specific for bicycles were deemed important possible improvement factors.

Another important dimension of bicycles on board is the attitude of the personnel on the train. The study from 2009 interviewed six employees on various train operators with services in Skåne. Their views were in general positive, however the improvement potentials mentioned were that there should be clear dedicated spaces where the passengers themselves could fasten the bicycles. Furthermore, it was explained that the information regarding rules and regulations should be made clear, for both personnel and passengers.

To have dedicated places for cycle storage, in contrary to shared areas, emerged to be preferred for both personnel and passengers (Envall et al., 2011). Dedicated places make it easy for cyclists to spot available places where they are not in the way of other passengers. Additionally, it is easier for train personnel to turn away passengers with bicycles when the dedicated spaces are full in comparison to shared space. Regulations for reservations may be a solution if a problem emerges with lack of space. However, according to the study, a large surplus in passengers with bicycles is not expected even when marketing the possibility and clarifying specific rules.

3.3 Soft Measures

As stated in the previous Section *3.1.3 Examples of Hard Measures*, the very first step in the Swedish Transport Administration's four-step principle (Trafikverket, 2018a), *re-think*, includes relatively low-cost measures like information and marketing. In Sweden these measures must be considered before any of the other steps, yet the measures can be regarded to belong in the first step be implemented together with later steps. Practically, the total effect of the package of measures may be increased compared to merely implementing technical, hard measures (Cerny & Daggers, 2016). Specifically for bicycle use, cycle infrastructure such as new lanes is according to McClintock ”neither a necessary nor a sufficient condition for high levels of cycle use” (McClintock, 2002). Other aspects like parking availability (both availability for cars and lack of bicycle parking), distance and urban environment need to be considered. However, the cultural attitude is stated to be most important and that to attain a significant increase of cycling also measures beyond infrastructure are required.

Several surveys confirm that the willingness of cycling depends on the conditions and more people would cycle if the circumstances were right (McClintock, 2002). Aspects such as weather, hilliness and distance as well as perceived or real safety issues must be considered, especially since these barriers can be exaggerated by personal perceptions that may not always be correct (e.g. the actual amount of rainy days). Infrastructure is often implemented on positive grounds but are frequently dealing with improving negative characteristics such as safety. In comparison, soft measures focus on the positive profits of cycling for instance. Some of the soft measures can be seen within concepts such as Mobility Management (MM) and Nudging.

A consultation between five experts within traffic planning, as part of a thesis at Lund University (Lindholm, 2016), proposed that measures within Mobility Management could be interpreted as Nudging. MM contains more or less Nudging techniques, depending on how the measures are designed and implemented. There is an apparent connection between the concepts; influencing people's behaviour and provide information to facilitate choices. In detail is MM practiced promoting sustainable travel behaviour while Nudging can be applied within several areas yet being about promoting the "right" choice (Forsell et al., 2010). Ergo, MM focuses on passengers to increase sustainable transport while Nudging intent on making the best choice the most attractive one.

Both types of soft measures that are brought up in this thesis consider behavioural change, here specifically for travel behaviour. A particular occasion when people tend to be more open to change travel behaviour is at times of large infrastructure projects (Ortmann & Dixit, 2017). If routes are needed to be changed due to distraction in the normal behaviour, people are more willing to experiment with new travel modes. Hence, this is an opportunity to use soft measures to change travel behaviour. However, the nature of human behaviour and responses is proven to be varying for the same transport policy tools (Mont et al., 2014). Due to the heterogeneity among people's behaviour and that these specific soft measures are relatively new, more research is required regarding decision variety in travel choices and people's reaction to different kinds of measures.

3.3.1 Mobility Management

Mobility Management is considered to be supplementary measures to infrastructure and technical solutions to meet sustainability needs for mobility (EPOMM, 2013). The reason for MM is subsequently to solve sustainability issues, environmental as well as social and health problems. Several countries are members of the European Platform On Mobility Management (EPOMM) where the concept may also be explained with the term *smart travel* or similar, depending on countries. Although MM has no exact definition as it changes with time and location (MAX, 2009), EPOMM defines it as:

> *"a concept to promote sustainable transport and manage the demand for car use by changing travellers' attitudes and behaviour".*

According to EPOMM (2013), Sweden focuses on attractive cities and climate. There are three strategies, namely *policies and law, fiscal measures* and *awareness raising and promotion*.

Typically MM consist of soft measures such as information and communication, that either aims to replace or enhance the effect of hard measures (MAX, 2009). Within urban transport, traffic planning and implementation of new public transport are considered as examples of hard measures. In comparison to these measures, MM often requires less investment financially. Most often MM measures gives the best effect when introduced together with other types of measures, in a so-called *package of measures* (Forsell et al., 2010). MM enhances the effectiveness of hard measures alone, while Nudging should be complementing MM in order to further increase the effectiveness. Within MM, measures are categorised to facilitate the overview

(EPOMM, 2013). Some are connected, but still described in their respective sections. The initially mentioned four categories below can be applied to make the bicycle-train system implementation more efficient, while the remaining categories are less applicable and described briefly to reinforce the comprehensive picture.

3.3.1.1 Information Measures

MM measures are demand oriented, where the informational measures are mainly based on travellers' demands (MAX, 2009). To reach out to and attract potential travellers, many different medias may be used depending on the target group(s). For instance, it could be services for information and trip advice at local mobility centres, often for public transportation but also other modes. Furthermore, an informative measure could be travel information through different technologies, or marketing of sustainable transport modes.

Information can be given for different purposes in the planning and implementation phases, in a preparatory stage for the trip and during the trip (Cerny & Daggers, 2016). The initial promotional information, connected to the planning and implementation, mainly aims to change the behavioural aspects of people's travel. When regarding the specific trip information such as information on platforms as well as websites and apps, it is more aimed for orientation and regulations of the transport mode in question. To facilitate and consequently increase the bicycle use together with trains, information that clearly states how to get to the platform with the bicycle and which carriage that allow access for bicycles is crucial.

3.3.1.2 Promotional Measures

This category concerns promoting alternative (sustainable) transport modes, provide information and raising awareness, and is supposed to encourage a voluntary change in behaviour (MAX, 2009). Hence, no new alternative to the car is brought forward, yet it is an attempt to actively promote the existing sustainable options. It could be advertising campaigns, promotion of alternative modes targeted for workplaces or PTA (Personalised Travel Assistance), to reveal options on how to reduce the car use.

3.3.1.3 Site-Based Measures

Commonly, traffic is originated from sites such as schools, hospitals or workplaces (MAX, 2009). Therefore, MM measures are in many countries site-based and the measures aims to handle the way in which people get to and from the site in question. The measures could be adapted to the conditions of the specific site with for example parking for bicycles and public transport stops. Usually, there are several measures to fulfil the need of the specific site and therefore may be a collection of other MM categories. It could for example include information and promotion of available alternative green options, evading congested time periods through compressed work weeks as well as secure bicycle parking facilities and so-called *car parking management*. According to MAX (2009), car parking management is a powerful tool to influence people travel behaviour through regulating the access to car parking connecting to a site. It could be in terms of monetary or space regulations as well as regulated individually according to certain criteria such as age.

3.3.1.4 Supportive and Integrating Actions

The category consists of measures not strictly used to improve mobility but that may have a high impact on how effective MM measures are (MAX, 2009). They are categorised as supportive since they may not be directly seen by the users. For example, it could be making the environment more susceptible to the MM measure introduction. *Car parking management* can be found within this measure category too, as well as tax regulations to make sustainable options more attractive.

3.3.1.5 Organisation and Coordination; Education and Training; Telecommunication and Flexible Time Organisation

Organisation and Coordination measures refers to the provision of MM services organised and coordinated across an area, bringing a sustainable alternative for the single car use (MAX, 2009). Examples of this is car-pooling, car-sharing and public transport on-demand.

Education and Training is the focus of integrating MM into education, for employees in hotels and mobility centres as well as in schools. It could for instance concern offering information and help regarding public transportation options.

To reduce the need of travel, companies and organisations can use techniques within *Telecommunication* or reorganise some of the work assignments through *Flexible time organisation*. It could be done by using network services to perform meetings and changing the procedure to reduce the number of times that patients need to appear for hospital visits for a certain treatment for instance. Opening hours could be altered or work hours flexible for some organisations and companies to lower the influence in rush hours.

3.3.2 Nudging

Just as Mobility Management does not have a set definition, it is not widely accepted exactly which measures are included in the relatively new concept of Nudging (Thaler & Sunstein, 2008). Nudging can be applied within several areas such as the food industry or energy consumption, while within the transportation sector Nudging may be a part of MM. Generally, Nudging is about how information is presented. The standard for supplying information is currently most using behavioural models relying on rationality (Mont et al., 2014). However, people are often biased, and their habits play a large role in the choices people make. Nudging is therefore using knowledge of behavioural science to design policies. The term originates from the book *Nudge: Improving Decisions About Health, Wealth and Happiness* by Thaler & Sunstein (2008) when describing behaviour change. The idea of libertarian paternalism is brought forward, being the basis of the nudge concept. They state that the freedom of choice still exists (libertarianism), but people are nudged to the choice which is the best for themselves (paternalism). All choices remain yet it is the choice architecture arranging the choice situation to encourage the wanted behaviour and gain the desired outcome. The best option - also as according to the individuals - is made the most attractive one. Further definitions than from Thaler & Sunstein (2008) have been brought forward to make it more specific, yet they all have in common to consider biases.

MM is as stated considered to be complementary measures to technical solutions (Mont et al., 2014). Likewise, nudges are regarded to assist hard measures such as infrastructure through changing behaviour to solve problems like climate change and impacts that influences the environment negatively. Generally, there are some nudging tools that can be used; offer default options for complex information, simplifying information to highlight the most important, change the physical environment to make the best option most convenient and communicate social norms, i.e. what others are doing. Nudges are often cost effective and through Nudging, other policy tools may be enhanced and the implementation faster (Lindahl & Stikvoort, 2015; Mont et al., 2014).

While changes in behaviour are sought for when using Nudging techniques, influencing personal values or attitudes is not (Mont et al., 2014). Nudges are meant to be used (and are most effective) when the desired behaviour is ideal also according to the individual(s) or when the desired option is unnoticeable and needs to be emphasised. Thaler & Sunstein (2008) claim some situations as being more efficient and receptive to nudges. Those circumstances are when choices have the properties described below.

1. Have delayed effect
2. Are complicated and with inadequate feedback
3. Have an equivocal relation to the outcome

Accordingly, Mont et al. (2014) describes nudges to be most effective when choices are made with low conscious consideration or through habits as well as when there are complex and unknown choices. Similarly, another report by Lunn (2014) states that nudges may be most relevant for policies directed to specific behaviour, spontaneous purchases and complex services (Lunn, 2014).

The idea to include behavioural viewpoints in policy making make the progress more predictable and easier to set up goals (Mont et al., 2014). Furthermore, it is a benefit that nudges conform with the so-called "ideals of the free market". However, the uncertainty of the effect in the real environment compared to a controlled study is a drawback as well as the difficulty of policy design with nudges. Some are sceptic to the extent of success specifically for nudges on societal scale problems such as climate change, why Marteau et al. (2011) mention that the description of nudges should include the intended target group, in what circumstances it may be effective and the expected time period for the effect to last (Marteau, Ogilvie, Roland, Suhrcke, & Kelly, 2011). To solely implement nudge measures is not seen as a sufficient strategy to change behaviour for large scale problems.

Consequently, it is important to consider that Nudging in policy making cannot replace harder measures for certain areas. Restricting choices may be the only policy that will be effective for certain desired changes. For instance, it regards desired changes related to larger problems like climate change. It is argued by Schlag (2010) that gaining the desired effect is more important than preserving the freedom of choice, and the desired effect is more likely to be reached through other, choice-restricting policies than through Nudging (Schlag, 2010). Furthermore, it is necessary to not use nudges as an excuse to exclude information. If so, Nudging may jeopardise democratic processes. Yet, nudges are often most effective when people are not well-aware of it. If people are conscious about the attempt to being nudged, the effectiveness of a rearranged choice architecture is significantly reduced.

Despite the difficulty of designing reliably successful policies of nudges, a substantial impact can be gained from implementing a Nudging strategy for the long term (Mont et al., 2014). The use of Information and Communication Technologies (ICT) are expected to further amplify the effect of nudges while enabling the nudges to be more personalised, e.g. through smartphone apps.

3.3.2.1 Personal Transport

Since a large share of Sweden's, as well as many other countries', greenhouse gases originate in traffic use, the strive to facilitate greener transport behaviour has been present for a long time (Mont et al., 2014). Yet, Nudging is a new concept to the personal transportation area. The transport market has obstacles preventing people from improving their travel behaviour, such as information barriers and transaction costs for changing travel mode. Unfortunately, the aforementioned three circumstances for effective Nudging may not be applicable to personal transport, but nudges can be used to make the preferable alternative easier to make, e.g. facilitate the use of bicycles. Moreover, one person's reaction to the same type of nudge can vary greatly, depending on the context for a certain moment (Mont et al., 2014). The circumstances within transport are always different in each new project, compared to the food or energy sector where the context and circumstances are easier to control.

A further challenge is the scale of the transport domain, where the effect does not show on an individual level but rather on societal (Mont et al., 2014). Therefore, the aspiration to change individual transport behaviour is generally lower than in the energy or food sector. To gain effects in transport, policies can focus more on health aspects and people's willingness to align with social norms (Elberg Nielsen et al., 2016). Regarding framing of information, Mont et al. (2014) claim that one of the most efficient ways to influence people's response is to concentrate on loss and risk aversion. To formulate the information in negative terms brings higher effect than the other way around since people seem to react stronger to loss than gains, i.e. loss aversion (Ortmann & Dixit, 2017). For transportation it could mean customised travel info and carbon calculators (Mont et al., 2014).

Although these measures are relatively cheap by themselves, the design and planning for them may risk that the total outcome is not the best in monetary terms in order to gain the desired change (Mont et al., 2014). To consider human behaviour in the development and implementation of policies is time demanding and requires specific knowledge to connect suitable measures for the policy aim. It is highlighted that Nudging should be implemented together with other measures that for example offer sustainable infrastructure, since the purpose of nudges is the increase of the desired effect of other measures.

3.3.3 Effectiveness of Soft Measures

Transport policies and approaches to deal with environmental issues for instance have been implemented for a long time. Although the effectiveness of strategies concentrated on individual behaviour change for private mobility has not yet been evaluated extensively (Mont et al., 2014). However, total MM programmes have shown reduction specifically in car use by 5-15 percent (Brög, Erl, Ker, Ryle, & Wall, 2009; Chatterjee, 2009). There is a lack of analyses for transport related Nudging approaches and the effectiveness depends deeply on surrounding factors, why the effectiveness is not yet confirmed with fixed number that can be applied universally (Mont et al., 2014). Table 3.1 presents effectiveness related to some specific cases in Nudging to give examples of success rates.

Table 3.1 Effectiveness of Nudging mechanisms from specific cases, simplified from Mont et al. (2014).

Nudge Mechanism	Mobility Applications	Effectiveness Evidence
Simplification and framing of information	Provision of clear information Changing framing to encourage cycling and walking Offering cycling training Offering personal travel plans	CO_2 reduction 19 percent average for 10 studies, some cases up to 35% One report showed 10% reduction of car use through personal travel plans
Changes to physical environment	Road and lane planning Urban design	As effective as infrastructural projects; hard measure
Use of descriptive social norms	Travel feedback programmes with social norms involved Smartphone apps to encourage physical activity	Mixed evidence and low validity due to small sample size One study implied 64% increase in walking for a certain time period. No reported reduction in other travel modes

As is presented in Table 3.1, cases are showing different effectiveness evidence. The fact that MM and Nudging are relatively new concepts in combination with the altering circumstances for every new project have restrained the findings of effectiveness evidence related to this thesis' topic. Of the sources investigating effectiveness, most are focusing on reduction in car use or increase in a certain travel mode, none specifically considering the combination of bicycle and train. Soft measures are also often used when implementing new hard measures, why it is difficult to see where the effect came from more specifically than the combination.

3.3.3.1 Critical Factors

The are some features that have been seen improving the effects of Nudging (Mont et al., 2014). When aiming to change people's standard transport mode choice, Nudging has been successful for applied in situations where the everyday life is changing, e.g. when moving. Simplified information, facilitating the change from (presumable) private car and the presence of easily accessible sustainable transport modes are important factors for effective nudges. Furthermore, the physical environment is an effective feature to influence travel behaviour, certainly when combining the change of appearance with other measures. Examples of changes in the physical environment are road lines, signs and humps to reduce speed.

Nudging can also be done through smartphone applications, with the social norm approach when enabling to share the progress (such as routes, distance and speed) on social media (Mont et al., 2014). However, the reported effectiveness is mixed, and tested for small groups leading to a higher uncertainty in the results. For example, one study presented in Table 3.1 reported an average increase of walking for 152 males using a smartphone application with accelerometer of 64 percent.

Since private mobility behaviour is affected by many elements, a factor important for success is the presence of policy packages that encourage better choices (Mont et al., 2014; UK Department for Transport, 2011). When regarding efforts to increase the use of bicycle in urban areas is the common factor of a policy package, consisting of several altering measures combined, shown to be important. These measures are implemented for a longer time period and together leading to a substantial increase in cycling. Examples of measures combined in successful cases for increased bicycle use are signed bicycle routes, coloured bicycle lanes, maintenance of infrastructure, techniques to shorten cyclists' routes, bicycle parking and allowing bicycles in rail carriages.

3.3.4 Examples for Implementation of Soft Measures

Since Mobility Management and Nudging for personal transport are so closely related are the following examples connected to both areas of soft measures. Concerning the case discussed in this thesis, bringing bicycles on board train carriages, nudges may be most effective when the desired behaviour is ideal according to the individual(s) or when the option is unnoticeable and needs to be emphasised. MM can be applied through informational and promotional measures as well as, for some cases, site-based supportive actions. Combinations of loss aversion, simplification of information and social norms can be combined to create nudges to increase the effectiveness of an opportunity to bring the bicycle on board.

3.3.4.1 Campaigns

The following section describes a few different specific campaigns used to increase the modal share for cycling, which could either be used more or less directly for the purpose of cycling or be interpolated to fit the case in this thesis. These campaigns do all have in common that the information and promotion is framed to be comprehensible.

3.3.4.1.1 Information Rings

A qualitative Nudging test was performed as a part of a thesis at University of Lund, Sweden (Lindholm, 2016). The target group was employees at the company Trivector in Lund, for which the thesis was performed, with evaluation through semi-structured interviews. The Nudging test was conducted through the making of five so-called information rings. Each ring was for different urban areas within the region of Skåne and held ten informative pages. The pages compared car with an electric bicycle in terms of for instance money savings, calories and expected life prolonging related to the distances from the respective urban areas to the office in Lund. Some of the pages had illustrations to enhance the message, and some words were enlarged for emphasis. Furthermore, the pages were shaped round, to additionally provoke interest. Foremost did the interviews show that the information rose awareness and discussion while perceived as customised. Some examples of the information on the pages, where the exact numbers relate to the specific urban areas, are translated below. The corresponding Swedish original versions are shown in Figure 3.11.

> "You save 24,600 SEK per year if you commute by electric bicycle instead of by car."
>
> "If you use the electric bicycle instead of the car all year round, you prolong your life with 3 whole years!"
>
> "You can eat an extra 3 chocolate bars of 100g – each week! If you use the electric bicycle to work 5 days a week. (Or you lose 13kg in one year by commuting with an electric bicycle)."

Figure 3.11 Examples of the information rings as part of a thesis at University of Lund (Lindholm, 2016).

3.3.4.1.2 Cycle nice!

The city of Malmö has had several campaigns to promote bicycling. One campaign called *Cykla fint!*, translated to *Cycle nice!*, was performed in 2011 and again in 2014 (Gatukontoret, 2014; Testbedstudio Arkitekter, n.d.-a). The goal was to increase the safety for cyclists and the sustainment of rules through mediating messages of how road users should behave with pictures and simple messages. The expectation was to create a better cycling environment and increase the modal share for bicycles (Testbedstudio Arkitekter, n.d.-a). The messages concerned information about gestures, obligatory cycling items and situations worth considering. Examples are shown in Figure 3.12 below.

"Instead of mind reading, show signs!"

"You who cycle very fast also need to be very kind."

"A well parked bicycle gives an inner satisfaction and is the foundation of which the society rests."

Figure 3.12 Visual representation of the messages for road behaviour.

3.3.4.1.3 No Ridiculous Trips by Car

The EU project Civitas Smile (Civitas, 2009) was a project aiming to improve sustainability issues such as air quality, health and safety through promoting cleaner fuel and intelligent door-to-door services. As a part of the 51 demonstration measures within the project did Malmö city have a campaign called *Inga löjliga bilresor*, i.e. *No ridiculous trips by car*, aimed to influence the amount of "ridiculously" short car trips (Gatukontoret, 2014). It consisted of several parts, e.g. a historical exhibition about cycling in Malmo (Testbedstudio Arkitekter, n.d.-b), dialogues with citizens about the bicycle's role and possibilities in the city (Gatukontoret, 2014), and orchestra homages for cyclists early on a Monday morning. Moreover, a competition was performed for the most ridiculous trip by car in order to increase the awareness of unnecessary use of cars where the winner (reporting the shortest car trip) won a bicycle (Örstadius, 2008). Another contest paid attention to the people who already were cycling and the reasons behind that (Testbedstudio Arkitekter, n.d.-b). Examples are shown in Figure 3.13 below.

Figure 3.13 To the left, example of historical exhibition poster. To the right, visualisation of competition of 16 bicycles (Testbedstudio, n.d.-b).

3.3.4.1.4 Buss Ohoj!

In Region Västra Götaland, VGR has an ongoing campaign to encourage people to use bicycles in combination with public transport as mentioned in Section *3.2.1.1 Region Västra Götaland*. The campaign includes 20 participants in Region Västra Götaland and Halland, who are chosen to borrow a folding bicycle for three months (HRV, 2017). There are some requirements for the participants, firstly that the bicycle should be used in combination with public transport to replace car trips. Furthermore, the participants are required to use the bicycle at least three times every week and to report their progress and usage every other week. The campaign was underway for two separate periods in 2017 with different participants. The health effects were noted for the participants in one of the campaign rounds. The participants should also work as ambassadors for the campaign. The drivers on the buses should be informed about the campaign and the rules regarding folding bicycles. The participants chosen for the campaign in 2017 were used to utilising public transport and bicycles in order to ensure that the folding bicycles are used. It was noted that this might give less weight to the health follow up as the participants already have relatively good physique (HRV, 2017).

The result of the campaign was overall positive. The participants were asked “Do you think your travel habits have changed during the project, if so, do you think these habits will stay?”. To this, 54 percent answered “Yes” or “Maybe” during the first project round, and 45 percent answered the same during the second project round (HRV, 2017).

The health conditions of the participants were divided into four category groups before and after the campaign.

1. Great need of lifestyle changes
2. Need of lifestyle changes
3. Good lifestyle and health
4. Very good lifestyle and health

The result of this was that the second group decreased by five percent and group four increased by five percent, indicating a general health benefit. However, all of the participants that had presented that their travel habits had altered answered “Yes/Maybe” to perceived health benefit from the project (HRV, 2017). Unfortunately, there were some instances where the participants noted that the bus drivers were opposed to the idea of bringing bicycles onboard.

3.3.4.2 Travel Planner; Website Information; Apps (ICT)

To ensure an accessible combined trip, there should be information on the website and other relevant places regarding ticket prices and restrictions. For the regions that do not allow bicycles on all departures, there should be the option to search for departure availability for bicycles (Küster et al., 2016). A feature that could simplify the information is to include bicycle as a travel mode in the online travel planner. This was mentioned previously in the report as an example in Malmö where the travel planner is used through Skånetrafiken, see Section *3.2.1.3 Region Skåne: Malmö*. In the application, a bicycle could be chosen as travel mode to and/or from the stations and it also has the option of bringing the bicycle on board. In the travel planner, it is possible to plan the total trip from point A to B with suggestions in terms of time for public transport and information of how to get to and from the stations with bicycle, together with approximated time (as is normal in online travel planners). The unique part about Skånetrafikens planner is the option to choose between the following alternatives regarding bicycles (Skånetrafiken, n.d.-a) presented below.

- Without bicycle
- Carry a bicycle all the way
- Cycle to the access station and park it there
- Cycle from the egress station where the private bicycle is located
- Cycle to and from the station with two separate bicycles

This differentiates to the more common travel planners where walking is the default and only choice in combination to public transportation.

Other apps specific to bicycle use could be route planners. They could be used in combination with bicycles if the application is used to access a station or to find the way from the egress station. Example of this as mentioned previously in Section *3.2.3 Denmark: Copenhagen* is the application “I Bike CPH” used in Copenhagen (I bike CPH, n.d.). The special feature of this route planner is the option to choose what kind of route you would prefer with three options.

- Fastest route
- Green route
- Best for cargo bicycles

3.3.4.3 Information Outside the Station

Other aspects of this multimodality before reaching the station is the importance of having clear directions along the bicycle path towards the stations (Küster et al., 2016). It is recommended to start the signage at least three kilometres before the station along the bicycle paths, and to direct the bicycles to the correct entrances for bicycle parking or access to platform. The signs could indicate distance and assumed cycle time.

The signs may not be analogue but could be a part of an ITS, Intelligent Transport System. One example of this is Dynamic Route Information Panels (DRIPs) (VerkeersNet, 2010). One example of this being implemented is in Amsterdam, connecting the bicycle path to ferry departures. The DRIPs show the departure time for several ferries (three or four) so that the cyclists can choose which one to aim for and adapt the speed accordingly. In order to let the cyclists adapt their speed, the signs need to be at a sufficient distance. The declaration of departure times on the signs reduce waiting times by the ferry terminal and it spreads out the travellers over different ferry departures (VerkeersNet, 2010). Similar signs are seen outside of Gothenburg beside the highways into the city, usually before the entrance to a commuter parking lot. The next bus departures are shown for the drivers to adapt their time for parking. Since it is already used within the region, adaptations of the system to target cyclists on bicycle paths would be a feasible solution.

Another intelligent information system is Variable Message Signs (VMS), popular within car-traffic on for example highways. They could however be used to specifically target bicycle traffic, as was tested in Copenhagen with start in 2017 (ECF, 2017). The main focus of the VMSs is to decrease congestion on bicycle paths, since Copenhagen has a relatively high modal share for bicycles. This would be done by suggesting alternate routes with less traffic and presenting travel time for this. The signs require data that is acquired through an extensive sensor network, set up to measure the number of bicycles at a specific crossing as well as the accumulated queue lengths (ECF, 2017).

The signs could furthermore be useful for conveying other information than solely alternative routes due to congestion. It could for example be used to warn cyclists of construction works or to promote events and happenings in the city. It is explained that the system could be improved and extended in the future to include measurements of the air quality, by measuring the air pollution for specific routes and processing that information to suggest the route with the best air quality (ECF, 2017).

There has not been a thorough evaluation of the signs in Copenhagen, due to the difficulty of quantifying bicycle traffic. However, during a survey to the cyclists of

Copenhagen, 60 percent answered “Yes” when asked “Do signs like these have value for you as cyclist in Copenhagen?” (ECF, 2018).

3.3.4.4 Information at Stations

While it is important to have good signage and information on the path to the station it is also important to have clear instruction while at the station and platform. There should be signs outside as to which entrance is preferred for bicycles and directions to bicycle garage if needed. Furthermore, there should be signs for bicycle access to platform if there is a difference in level, through bicycle ramps for stairs or elevators (Küster et al., 2016).

There should be markings on the platform as to where the bicycle carriage or simply the carriage that allows bicycles stops. This should be done in order to prevent confusion and collision hazards on the platform but also to prevent delays from unloading and loading bicycles. For long trains (not commuter) there could instead be clear signage as to which carriages allow bicycles, there could also be announcements (Küster et al., 2016). In addition to the signage and markings on the platform, there could be clear markings on the train as well, as to which carts allow bicycles. As mentioned earlier this is done in Denmark on the S-tog which has markings on the trains, but also on the doors, where one end of the bicycle cart is for entering and the other is for exiting creating a flow to minimise collision risk (DSB, n.d.-b).

4 Results of Survey

Surveys are used extensively to gain knowledge about opinions for policy making (Mont et al., 2014). While there is a possibility to gain a large sample size, the amount of information is often less as people generally do not respond to extensive surveys. Furthermore, the answers may be biased by the notion of the respondents' behaviour. Answers may even be dishonest if respondents supply answers perceived as socially acceptable instead of real opinions (Mont et al., 2014). Finally, there is only a possibility to confirm correlation and not the reason for the connection. With these aspects in mind, the following survey was formulated to gain the most relevant information as possible within the timeframe and extent of this thesis. The results are introduced below, after that the analyses are presented.

4.1 Outcome of Survey

The results of the survey are presented in the following section with graphs and pie-charts for an easy overview of the total 608 people who responded the survey. Some questions and answers have been simplified for the presentation of the results below. For the full survey questions and answers, see Appendix I and II. As can be seen in Figure 4.1, almost half of the respondents, 284 people, were either living, working or studying in the focus region for this thesis; Region Västra Götaland. While 12 people, representing two percent, answered "Other". These respondents are neither living nor working or studying in the desired regions of study and were consequently excluded for the rest of the survey, leaving 596 respondents for most of the questions.

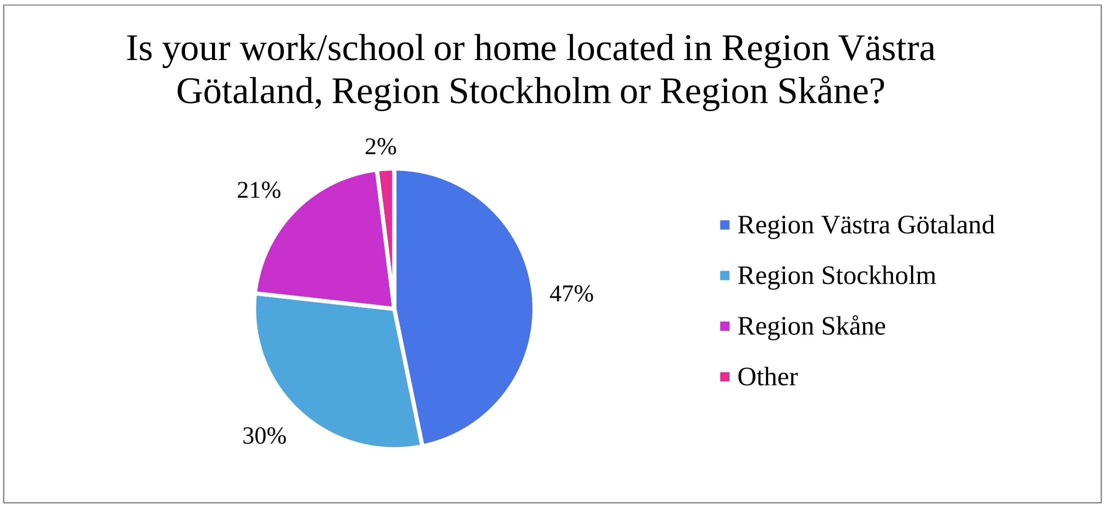
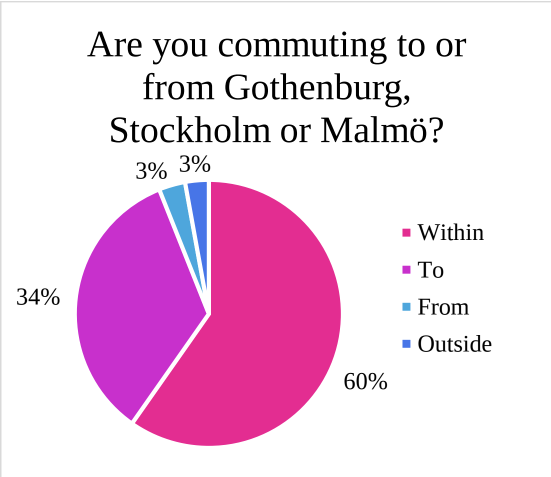


Figure 4.1 Question 1 from the survey.

Most respondents answered that their daily commute was "Within the city", see Figure 4.2 to the left. The results showed that it was more common to commute "To" the city as opposed to "From", specifically more than ten times more common. This is coherent with what is stated in Section *3.1.1.1. Region Västra Götaland* where the majority are recorded to be commuting to the main municipality rather than from. Furthermore, the data had to be modified due to the possibility of free text answers. The answers that were put into the category "Within" were those who manually explained that they do not commute or that they have walking distance to their workplace or school. Those who specified they commute by train were put into the category "Outside". Figure 4.2

shows to the right that approximately a third of the respondents answered that they use train as part in their daily commute.



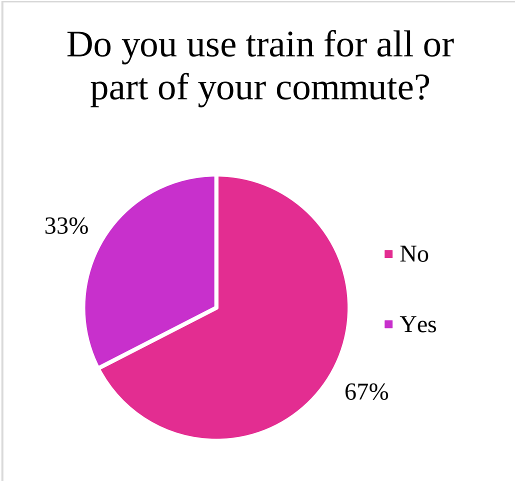


Figure 4.2 Question 2 and 3.

The following three questions were only answered by those reporting train use as part of their commute. Figure 4.3 presents that of the 194 people commuting by train, 43 percent report a use of "5 times or more" per week. It was assumed that people reporting "Less than 1 times a week" was non-regular commuters, which is represented of ten percent of the train respondents, while the remaining 90 percent was considered as regular train users.

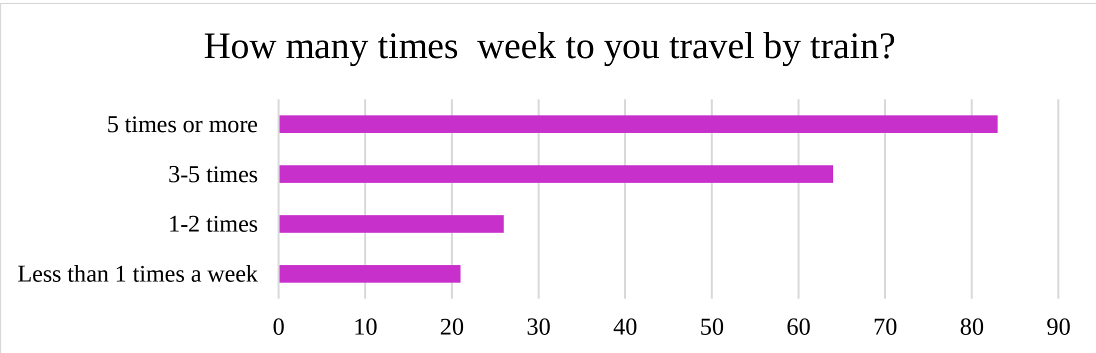


Figure 4.3 Question 4.

When asked about travel mode before and after the train journey, 42 percent and 28 percent reportedly reach access train station by "Walking" or "Public transport" respectively, as presented in Figure 4.4. "Bicycle shorter than 2 km" and "Bicycle longer than 2 km" as well as "Car longer than 2 km" all have around nine percent. A less common alternative was "Car shorter than 2 km".

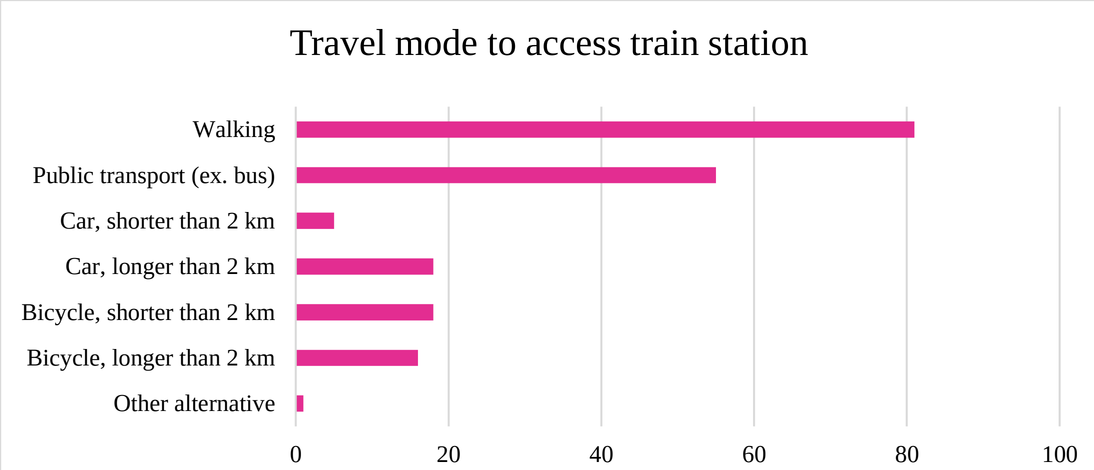


Figure 4.4 Question 5.

The travel mode from the egress station could differ from mode to the access station, why a separate question was formulated for this. Figure 4.5 presents the travel mode from the egress train station to work or school. The results stated that 65 percent answered "Walking" and 30 percent represented "Public transport". However only five percent stated one of the other alternatives, showing less diversity in the travel mode from the egress than to the access station.

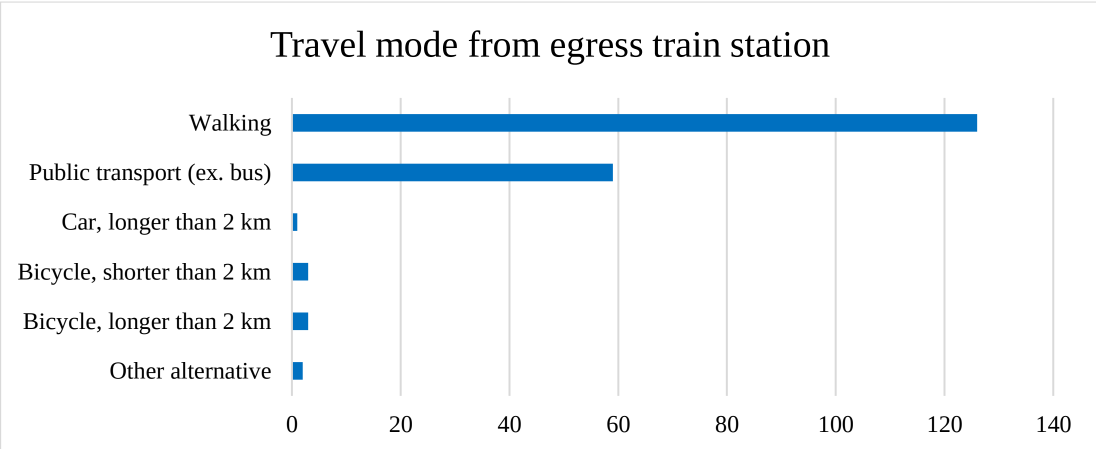


Figure 4.5 Question 6. NB: The scale for the x-axis is not the same as Figure 4.4.

The remaining questions were answered by all respondents. The desire was to gain a maximum of two answers per respondent in questions 7-10. However, due to the limitations of the free online tool Microsoft Office Forms and respondents not following the guidelines of the questions, some respondents answered three or more alternatives. Nevertheless, all answers in these preference questions were regarded as equally significant. Figure 4.6 presents reasons for using a bicycle, not necessarily connected to a train trip, with 986 answers, where 19 percent stated that they do not cycle at all. The two most common reasons for cycling was "Flexible time-wise" and "Health and wellbeing" with 22 percent and 21 percent respectively. 15 percent of the answers stated that cycling is "Flexible in comparison to public transport" which could be for example that there is no need for transits (this example was stated in the answer alternative of the survey, see Appendix I and II). Furthermore, eleven percent of the answers stated the reason to be "Environmentally friendly" and nine percent "Avoid crowded public transport".

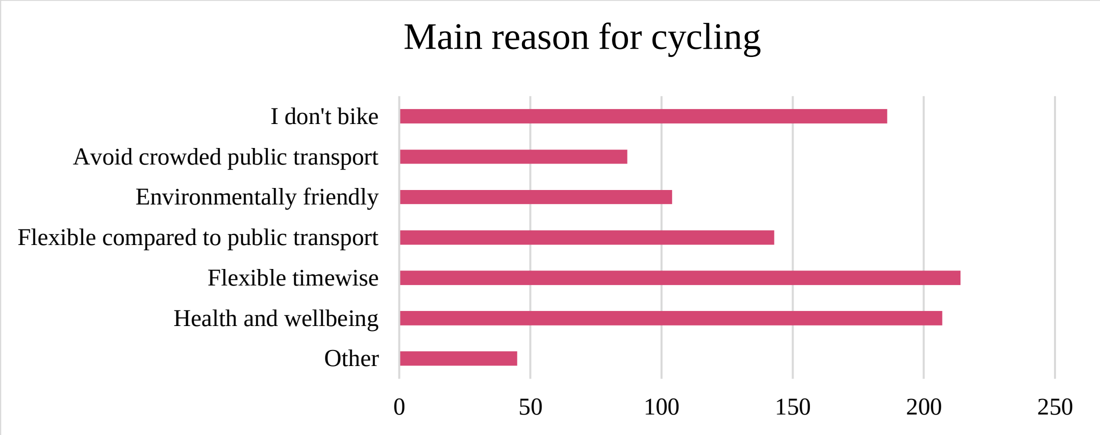


Figure 4.6 Question 7.

Figure 4.7 presents reasons for when not cycling, not necessarily in combination with train. This question got 871 answers due to the possibility of multiple choices, explained in the previous paragraph. The alternative "Too exhausting/do not want to" was the most common reason for not cycling with 29 percent. 25 percent of the answers stated that "The distance is too long". The lowest percentage was one percent for "Lack of parking at destination", which consequently could be viewed as an area that is not needed to focus on. Furthermore, the destination parking is most often handled by private forces and not the region.

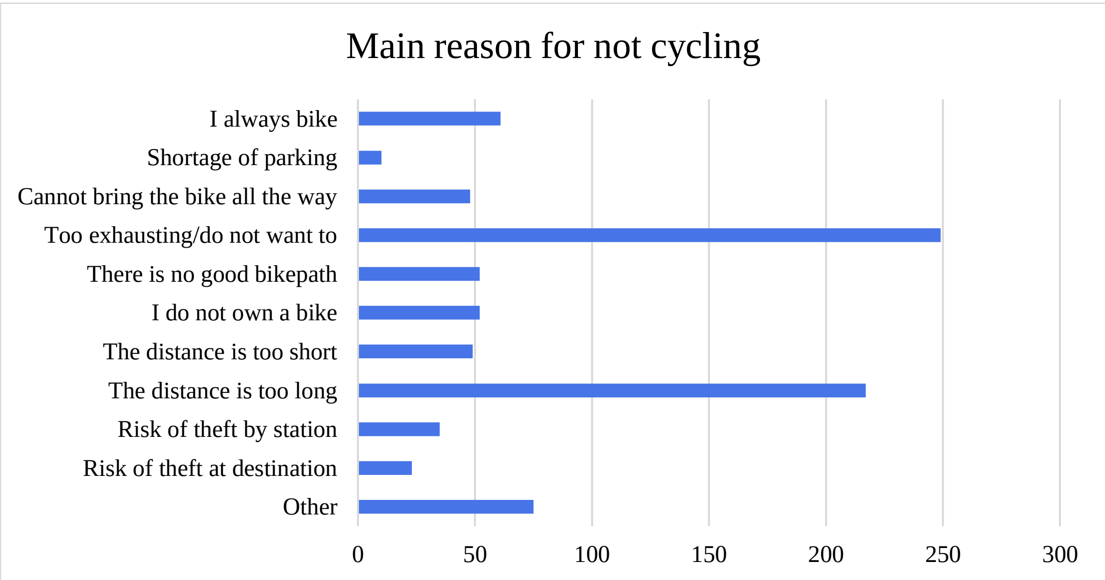


Figure 4.7 Question 8.

Figure 4.8 shows how often the respondents have brought a bicycle on board within the last twelve months. There was however only ten percent of the respondents that had brought the bicycle the last year, compared to 20 percent reported from a survey in Region Skåne (only asking train passengers). See Section *3.2.4 Previous Survey for the Swedish Transport Administration* for more information.

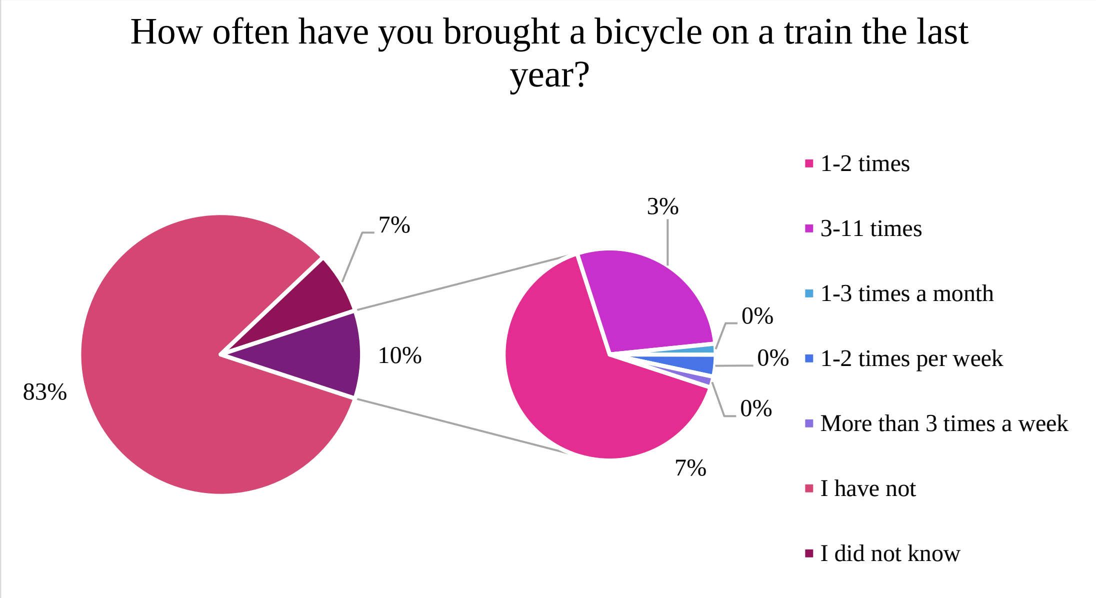


Figure 4.8 Question 9.

Figure 4.9 presents the main reason for when the respondents have not brought a bicycle on board. No person responded, “Risk of theft on board the train” as a reason while “Unclear rules and information”, “Too high cost”, “Lack of space on the train” and “Uncertainty of space” were rather common. There were some modifications that had to be done to the data, due to the possibility of adding a free text answer. The free text answers that could be categorised into pre-existing categories were done so, and the remainder were put into a new category labelled as “Other”. For the free text answers related to that the respondent does not own a bicycle, do not cycle or has not had the need to bring a bicycle on board the train, their answers were put into the category “I am not interested in the possibility”. For those who responded that train is not a viable option for their commute, the answers were put into the category “I rarely use the train” The most common reason, as all respondents got this question, was “I rarely travel by train”.

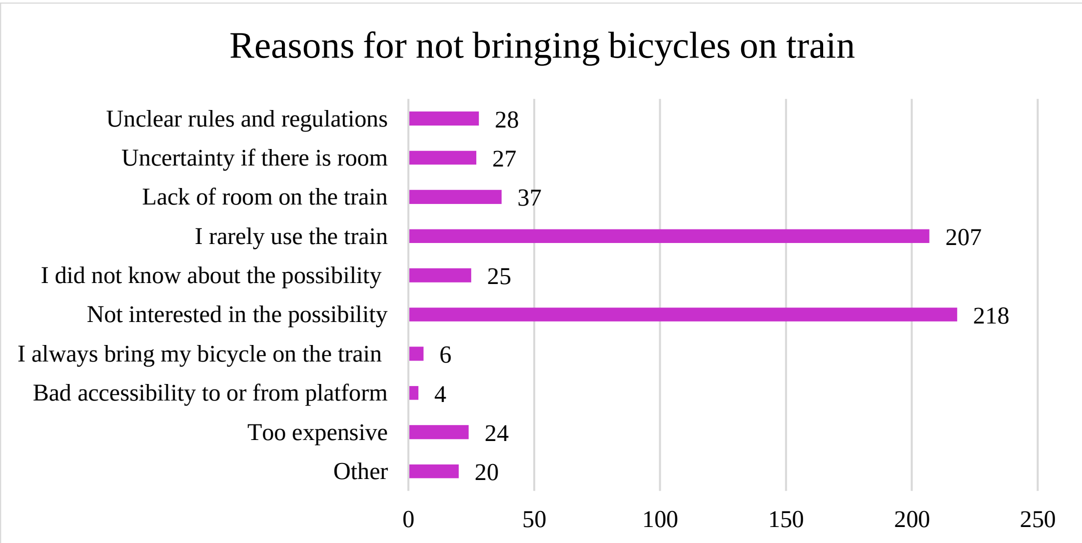


Figure 4.9 Question 10.

Following are some examples of what the answers that were put into the category “Other” were. There were several answers explaining that their trains did not allow bicycles onboard, mostly for respondents living in Stockholm as it is banned on the metro as well as most train lines there. There were also people mentioning the time limitations on some trains as to why is would not work for their commute. Another answer was that the respondent felt that they usually have too much luggage with them.

The desired outcome question was if the respondent would use the bicycle more than they did at the time of answering the survey, if the possibility to carry a bicycle on board train would be improved. Examples of development could be improvement of reasons in previous questions, where applicable. Figure 4.10 shows that 46 percent reportedly would either as part of the commute, for leisure purposes or both.

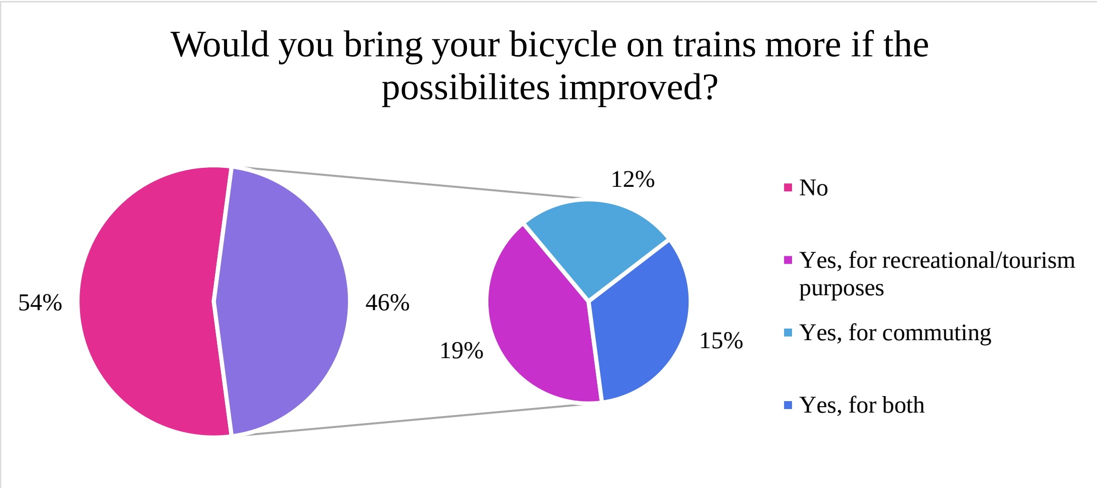
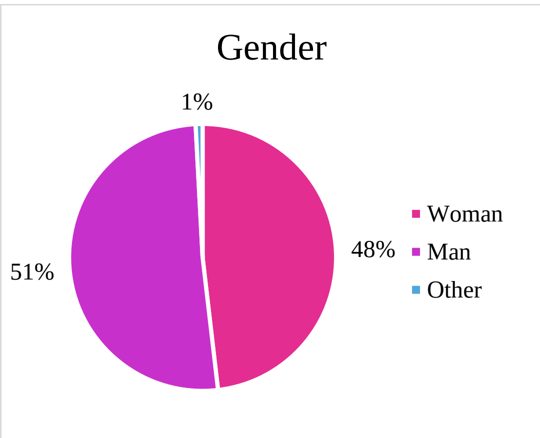


Figure 4.10 Question 11.

Figure 4.11 present the distribution for the respondents in terms of gender and age.



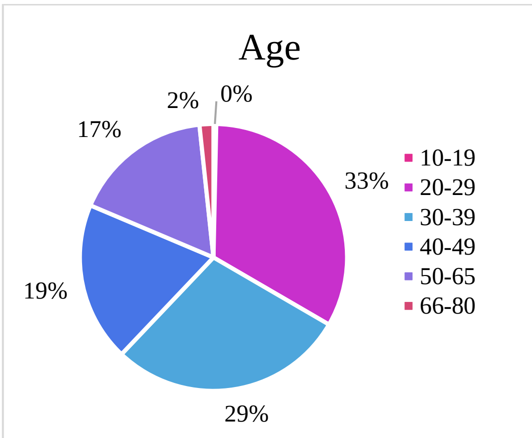


Figure 4.11 Question 12 and 13.

4.2 Binomial Logistic Regression Model

The statistical model was built on a part of the results from the survey. As mentioned in the methodology, Section *2.3.3 Model Set Up*, the answers that were applicable to the model were the ordinal or nominal, as presented in Table 4.1. The choice set used was from the respondents that answered that they used the train regularly in their commute. Therefore, the sample size for the analysis got cut from the total of 608 to 194. Additionally, some further respondents were removed as they did not fit into the parameters of the model, as explained in the methodology chapter, why the sample narrowed down to 188 people.

Table 4.1 Variables used in SPSS.

Question	Answer Options
Commuting within the city or outside/over city boundaries	Within To, from or outside city
Frequency of train use per week	< 1 1-2 3-5 > 5
Distance from home to access station	< 2km > 2km
Distance from egress station	< 2km > 2km
Gender	Woman Man
Age	20-29 30-39 40-49 50-65
If the respondent has taken the bicycle on train the last 12 months	No Yes
If the respondent would use the bicycle more (depending on their stated reasons)	No Yes

The following section describes the tests of accuracy for the binomial analysis and importance of the variables. Further on, the probabilities for several differently combined cases are presented. The probabilities are calculated as described in the methodology chapter, Section *2.3.1 Mathematical Framework*, with the dependent variable being the last line in Table 4.1. where the two parameters for the outcome in this case are “Yes” or “No”. The reference category for this model is “No”.

4.2.1 Statistical Significance

The theory behind the statistical tests is described in Section *2.4.2. SPSS Software*. For the model to be significantly better than the model from Block 0, where no variables are included in the model, the sig.-value should be below 0.05 in the Omnibus test for Block 1, where the variables are included. The sig.-value is not below 0.05 for this regression model yet is it below 0.1 and hence is Block 1 moderately better than Block 0. This is presented in Figure 4.12.

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	17,296	11	,099
	Block	17,296	11	,099
	Model	17,296	11	,099

Figure 4.12 Result from SPSS model of Omnibus test of the final model.

The Hosmer and Lemeshow test presented a chi-square value of 6.586. The degrees of freedom are eight and consequently, the number of groups used in the goodness-of-fit calculation amounts to ten as in a usual case. The test implies a good fit of the model if the sig.-value is exceeding 0.05. Figure 4.13 below presents that the regression model a good fit according to the test method Hosmer and Lemeshow.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	6,586	8	,582

Figure 4.13 Result from SPSS model from the Hosmer and Lemeshow test.

According to the classification table, the overall correctness for predicted against observed values was 59.0 percent. The downward diagonal from left to right shows the correctly predicted answers, while the opposite diagonal presents the incorrect. A value of 50 percent is the equivalent of tossing a coin, that the prediction in that case is not completely reliable. A value under 50 percent would have less prediction that a coin toss, hence a worse model than chancing. A value over 50 percent, as in this case, presents a prediction that is superior to that of a coin toss. However, the value does not correlate to a great model where around 90 percent or more would be preferable. The values from the model is presented in Figure 4.14.

Classification Table[a]

			Predicted		
			If respondent would bring their bike more on train or not		Percentage Correct
	Observed		No	Yes	
Step 1	If respondent would bring their bike more on train or not	No	53	35	60,2
		Yes	42	58	58,0
	Overall Percentage				59,0

a. The cut value is .500

Figure 4.14 Result from SPSS model with classification table.

The final model generated *B*-values for all parameters within their respective variable as well as an intercept, B_0, fit for the model. The intercept is called *Constant* in SPSS, seen furthest down in Figure 4.15, and amounts to 1.442. The last *B*-value in each variable category is 0 and hence not presented in the table generated by SPSS. The reference category is “No” for the dependent variable. The dependent variable, i.e. if the person would bring their bicycle onboard more if the circumstances improved, is the one for which a probability can be calculated.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Commuting within or outside/over city boarders (1)	,057	,360	,025	1	,874	1,058
	Frequency of train use			1,319	3	,725	
	Frequency of train use(1)	,261	,548	,227	1	,634	1,299
	Frequency of train use(2)	,532	,514	1,070	1	,301	1,702
	Frequency of train use(3)	,009	,362	,001	1	,980	1,009
	Distance from home to access train station(1)	-,295	,328	,812	1	,368	,744
	Distance from egress train station to work/school(1)	-,234	,358	,428	1	,513	,791
	If respondent has brought bike onboard or not(1)	-1,703	,530	10,326	1	,001	,182
	Gender(1)	,116	,318	,132	1	,716	1,122
	Age			1,965	3	,580	
	Age(1)	,573	,446	1,651	1	,199	1,773
	Age(2)	,165	,473	,122	1	,726	1,180
	Age(3)	,327	,505	,420	1	,517	1,387
	Constant	1,442	,717	4,040	1	,044	4,227

Figure 4.15 Outcome from SPSS with B-values and intercept.

The significance of each variable was shown by running a Binary logistic regression but with "Backward: LR" method (rather than the pre-set "Enter" method). In each iteration, i.e. step, the least fitting variable was excluded until only the variables statistically significant to the model remained. Variables excluded in each step when performing a "Backward: LR" method, with sig.-value > 0.05:

Step 1	-
Step 2	Commuting within or outside/over city borders
Step 3	Gender
Step 4	Frequency of train use
Step 5	Age
Step 6	Distance from egress train station to school/work
Step 7	Distance from home to access train station

The variable "If the respondent has brought the bicycle or not", within the last 12 months, was the most significant and best fit for the model (with a sig.-value of 0.001 for this method). Therefore, it was not excluded in the previous test, which excluded all other six variables. The total model was better than the intercept-only, i.e. Omnibus test with sig.-value < 0.05, for step 2. Moreover, the Overall model fit implied a good fit with values sig. > 0.05 for Hosmer and Lemeshow in all steps and sig. < 0.05 (0.027) in step 2 where the variable "Commuting within or outside/over city borders" was excluded. The best overall percentage of predicting right was for step 4 with 60.1 percent, when three variables had been excluded.

4.2.2 Calculations

From the binomial logistic regression model, probabilities may be calculated for persons with specific properties. Since the model had seven variables, the number of combinations for a person would result in too many calculations if all were to be examined. Therefore, some chosen properties were studied that were deemed to be more interesting, resulting in 20 calculations. The chosen (fictional) people to investigate in this case was chosen to be the first alternatives in each variable except for the train use frequency variable. It was reasoned to be more interesting to investigate a case person using the train 1-2 times per week than less than once. This choice set resulted in Person 1 below, with Equation 4.1-4.3. The intercept, i.e. Constant, was generated to 1.442 as presented in Figure 4.15 and the *B*-values correspond to their parameter.

<u>Person 1</u>: intercept + B_i

$$U_{1,yes} = 1.442 + 0.057 + 0.532 - 0.295 - 0.234 - 1.703 + 0.116 + 0.573 = 0.488 \quad (4.1)$$

$$U_{1,no} = 1 \quad (4.2)$$

$$P_{1,yes} = \frac{e^{U_{1,\text{yes}}}}{e^{U_{1,\text{yes}}+1}} = 0.620 = 62.0\% \quad (4.3)$$

For the next case person, the variable most significant to the model was changed; for Person 2 the "If the respondent has brought the bicycle onboard". The calculation for Person 2 is seen in Equation 4.4-4.6 below.

<u>Person 2</u>: intercept + B_i as Person 1, except has brought bicycle on train before

$$U_{2,yes} = 1.442 + 0.057 + 0.532 - 0.295 - 0.234 + 0 + 0.116 + 0.573 = 0.488 \quad (4.4)$$

$$U_{2,no} = 1 \quad (4.5)$$

$$P_{2,yes} = \frac{e^{U_{2,\text{yes}}}}{e^{U_{2,\text{yes}}+1}} = 0.899 = 89.9\% \quad (4.6)$$

Comparing these two calculations, where the alternated variable was statistically significant and influencing the model, people who have brought the bicycle are before more inclined to bring the bicycle more than currently, if the circumstances were improved. Both case persons 1 and 2 are also presented in Table 4.2 further down. The numbers are the same as in the calculations above, with the respective variable shown to the left in the table.

Afterwards, the changed variables, resulting in each new case person, were the next most important to the model according to the method "Backward: LR" presented above, combined with the previously changed variable(s) and so forth. The calculations for the rest of the case persons are presented in Tables 4.3-4.7. The cells marked with bold are the parameters differing from the origin Person 1 and the grey are not altered for any case person as they were the least significant for the model in SPSS, see Section *4.2.1 Statistical Significance of Model.* The total calculation of probabilities with numbers is shown in Appendix III.

Table 4.2 Probability for Person 1 and 2, where the bold are the changed parameters. The considered variable is if the person has brought a bicycle on board within the last 12 months or not.

Variable	Person 1		Person 2	
Intercept	-	*1.442*	-	*1.442*
Commute	Within city	*0.057*	Within city	*0.057*
Frequency	1-2	*0.532*	1-2	*0.532*
Distance 1	< 2km	*-0.295*	< 2km	*-0.295*
Distance 2	< 2km	*-0.234*	< 2km	*-0.234*
Brought Bicycle	No	*-1.703*	**Yes**	***0***
Gender	Woman	*0.116*	Woman	*0.116*
Age	20-29	*0.573*	20-29	*0.573*
Utility	*0.488*		*2.191*	
Probability of yes	62.0 percent		89.9 percent	

Table 4.3 presents the results for Person 3 and 4, where Person 3 only has the next best variable changed, i.e. the distance from the egress train station to work or school. Person 4 has both two most significant variables changed, marked in bold. The probabilities of increased frequency of carrying a bicycle on board are slightly higher for both person 3 and 4 when the distance from egress train station is higher than two kilometres, compared to Person 1. The increase is somewhat higher for a person who has not brought a bicycle before, roughly five percent (comparing Person 1 and 3), in comparison to someone who has, two percent (comparing Person 2 and 4).

Table 4.3 Probability for Person 3 and 4. The considered variable is the distance from egress station to work/school and in combination with if the person has brought the bicycle on board within the last year.

Variable	Person 3	Person 4
Intercept	-	-
Commute	Within city	Within city
Frequency	1-2	1-2
Distance 1	< 2km	< 2km
Distance 2	**> 2km**	**> 2km**
Brought Bicycle	No	**Yes**
Gender	Woman	Woman
Age	20-29	20-29
Utility	0.722	2.425
Probability of yes	67.3 percent	91.9 percent

Table 4.4 presents case persons 5-8, where the other distance variable also has been considered, i.e. the distance from home to access train station, in combination with the previously changed parameters. Person 5 and 7 relates to 1 and 2 with the changed distance. With only the distance from home to access station changed the probability is somewhat higher than for the distance from egress station to school or work. The combination of a person with distances over two kilometres both before and after the train trip segment is however the one with the largest increase.

Table 4.4 Probability for persons 5-8. The further considered variable is the distance from home to the access station.

Variable	Person 5	Person 6	Person 7	Person 8
Intercept	-	-	-	-
Commute	Within city	Within city	Within city	Within city
Frequency	1-2	1-2	1-2	1-2
Distance 1	**> 2km**	**> 2km**	**> 2km**	**> 2km**
Distance 2	< 2km	**> 2km**	< 2km	**> 2km**
Brought Bicycle	No	No	**Yes**	**Yes**
Gender	Woman	Woman	Woman	Woman
Age	20-29	20-29	20-29	20-29
Utility	0.783	1.017	2.486	2.720
Probability of yes	68.6 percent	73.4 percent	92.3 percent	93.8 percent

The further considered variable was "Age", as it was regarded to be interesting to see differences between age groups. Table 4.5 shows Persons 9-12 where the age changed from the span 20-29, which was the first parameter value, to 30-39. As can be seen do the probability of increased frequency of carrying a bicycle on board decline for ages 30-39 compared to 20-29 years.

Table 4.5 Probability for persons 9-12. The further considered variable is Age, here 30-39.

Variable	Person 9	Person 10	Person 11	Person 12
Intercept	-	-	-	-
Commute	Within city	Within city	Within city	Within city
Frequency	1-2	1-2	1-2	1-2
Distance 1	< 2km	< 2km	**> 2km**	**> 2km**
Distance 2	< 2km	< 2km	< 2km	**> 2km**
Brought Bicycle	No	**Yes**	**Yes**	**Yes**
Gender	Woman	Woman	Woman	Woman
Age	**30-39**	**30-39**	**30-39**	**30-39**
Utility	0.080	1.783	2.078	2.312
Probability of yes	52.0 percent	85.6 percent	88.9 percent	91.0 percent

The variable "Age" contained four parameters analysed in SPSS. Table 4.6 shows probabilities of persons aged 40-49. The rest of the parameters are changed like in Table 4.5. The probabilities are higher than for age span 30-39, but still lower than for those aged 20-29 years.

Table 4.6 Probability for persons 13-16. The considered Age parameter is 40-49.

Variable	Person 13	Person 14	Person 15	Person 16
Intercept	-	-	-	-
Commute	Within city	Within city	Within city	Within city
Frequency	1-2	1-2	1-2	1-2
Distance 1	< 2km	< 2km	**> 2km**	**> 2km**
Distance 2	< 2km	< 2km	< 2km	**> 2km**
Brought Bicycle	No	**Yes**	**Yes**	**Yes**

Gender	Woman	Woman	Woman	Woman
Age	**40-49**	**40-49**	**40-49**	**40-49**
Utility	0.242	1.945	2.240	2.474
Probability of yes	56.0 percent	87.5 percent	90.4 percent	92.2 percent

The last age parameter in SPSS was 50-65, with probabilities presented in Table 4.7. The rest of the parameters are changed likewise as in Table 4.5. People aged over 50 are the ones least likely to bring their bicycle on board more according to the binomial model.

Table 4.7 Probability for persons 17-20. The considered Age parameter is 50-65.

Variable	Person 17	Person 18	Person 19	Person 20
Intercept	-	-	-	-
Commute	Within city	Within city	Within city	Within city
Frequency	1-2	1-2	1-2	1-2
Distance 1	< 2km	< 2km	**> 2km**	**> 2km**
Distance 2	< 2km	< 2km	< 2km	**> 2km**
Brought Bicycle	No	**Yes**	**Yes**	**Yes**
Gender	Woman	Woman	Woman	Woman
Age	**50-65**	**50-65**	**50-65**	**50-65**
Utility	-0.085	1.618	1.913	2.147
Probability of yes	47.9 percent	83.5 percent	87.1 percent	89.5 percent

From the considered combinations of fictional people, where the one with the highest probability is Person 8 with 93.8 percent and the lowest Person 17 with 47.9 percent. Person 17 has not brought the bicycle on board within the last year, has lower distance than two kilometres for both before and after the train trip segment and has the highest age span of the investigated. Person 8 on the other hand has brought the bicycle within the last year, has longer than two kilometres for both distances and is within the lowest age span of 20-29 years.

The focus group should therefore according to this model be people with longer than two kilometres from train stations, especially at the egress station within the city. Gender did not play a significant role according to the model. Firstly, the variable here was not statistically significant, and secondly the influence of this parameter was very small in comparison to others. Furthermore, the age focus group, more inclined to increase their use of bicycle on board, should be 20-29. Moreover, the age span 40-49 showed the next highest probabilities why they could be a separate focus group as well. The most important variable was if people has brought their bicycle on board before, why it should be focussed on getting people to try the possibility in the first place, especially since many people did not know about the possibility at all as seen by the survey responses.

4.3 Data Analysis

The total responses amounted to 608 answers. However, twelve people responded that they did not either live, work or study within the regions desired for the study. Therefore only 596 answers, or a part of them, are analysed further in this section. The alternative "Other" left opportunity to describe more in detail, that was however changed in some cases in order to enable a relevant analysis. Some of the free text answers were merely a rewritten response of an alternative, where these were changed to their respective alternative, while others were deemed to be relatively close to one of the given alternatives and were changed to that for simplification.

The question of train use was formulated in a way that people that may travel by train often but not as a part of their commuting stretch got to answer "No" for the purpose of this study with focus on commuters. Therefore, some frequent train travellers may not be included in the following analysis. Of those 194 people answering that they travel by train in their commute, the age distribution was as seen in Figure 4.16. From the further analysis, the binomial logistic regression model, it was concluded that age spans 20-29 and 40-49 were more inclined to have a higher probability of carrying a bicycle on the train. Of the total respondents in Sweden's three big city regions where 36 percent aged 20-29 and 20 percent 40-49. For Region Västra Götaland were 56 people (i.e. 29 percent of total train user respondents) reportedly train users, with 21 percent in the 20-29 span and 32 percent in 40-49. The age groups more likely to bring a bicycle on board more, according to the binomial model, where in total 56 percent for Sweden and 53 percent for Region Västra Götaland. If the sample size is assumed to represent reality is the percentage susceptible to MM and Nudging rather large.

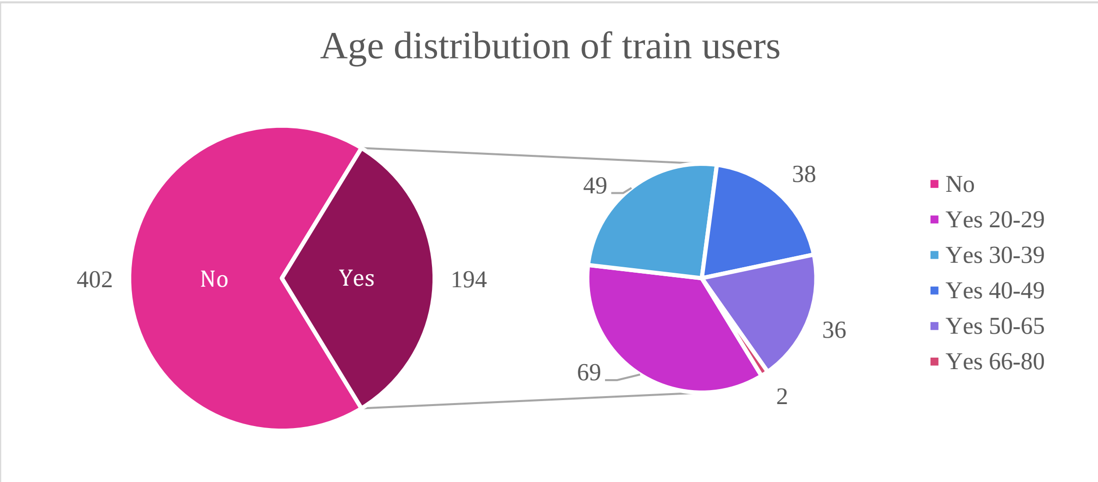


Figure 4.16 Distribution of age spans for train commuters.

Noteworthy is that about 80 people in Stockholm stated that they use train although they reportedly are commuting within the city. The conclusion from that could be that these people are referring the metro system as train, which was not the intention but realised in hindsight. Therefore, it could be argued that all or some of these people could shift from "Yes" to "No" in train use, leading to a distribution that less than 25 percent "Yes" to use of train.

According to the logit model was the most important variable if someone has brought a bicycle on board before. Approximately ten percent of all respondents stated that it was the case. 21 people, i.e. 35 percent, of those answered that they had brought a bicycle on board more than twice the last year, deemed to have used it repeatedly. The people answering "1-2 times" were 39 people, 65 percent, of those who had brought a bicycle on board. Of the total cycle passengers, the age distribution for less frequent cycle passengers (1-2 times) was as shown to the left in Figure 4.17 and of those deemed being re-occurring cycle passengers were the distribution as to the right in Figure 4.17. The age distribution varied slightly between the two cases. The share of younger people, 20-29 years, was higher for those having brought a bicycle multiple times the last year in comparison to once or twice, with twelve percent difference. The opposite was true for ages 40-49 where it was twelve percent fewer that had brought a bicycle 1-2 times in comparison to the re-occurring.

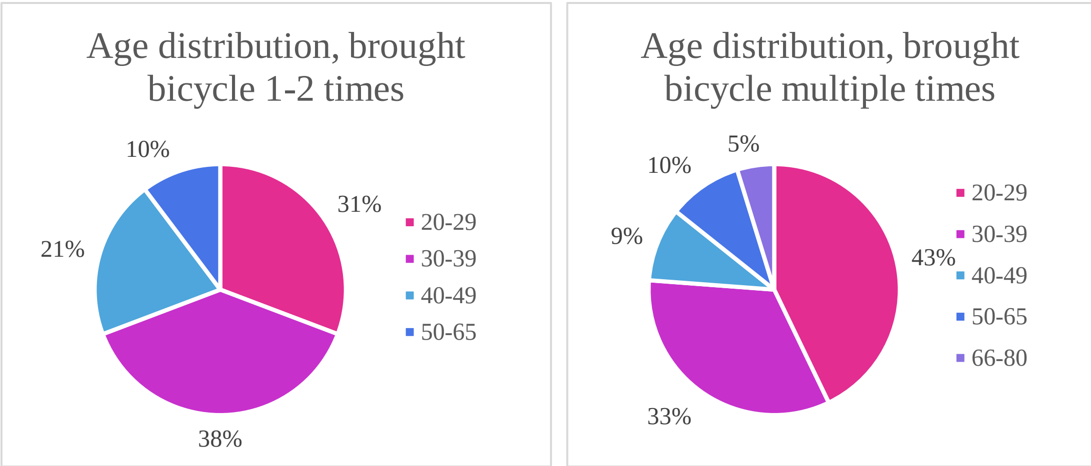


Figure 4.17 Distribution of age spans for respondents having brought a bicycle on board a train once or twice the last year to the left and multiple times to the right.

A similar question was asked in the Swedish Transport Administration's survey in 2009. There were 22 percent (Envall et al., 2011) of all respondents who had brought a bicycle on board the train in the previous year compared to ten percent for this thesis' survey. However, differences were that this survey was more general and including with three city regions as well as people not using train services regularly. A third of respondents stated that they regularly travel by train, see Figure 4.2. The survey in 2009 only included passengers on trains in Skåne region. Furthermore, a common reason for not having brought a bicycle on board was that they rarely travel by train. Mutual for both surveys were that a majority of cycle passengers stated that they had only tested the possibility 1-2 times, 65 percent and 66 percent for the survey performed by Envall et al. (2011), respectively.

Since it was concluded from the binomial model that cycle passengers were more likely to say yes to whether they would bring the bicycle more if circumstances were improved than other passengers, Figure 4.18 shows the distribution for cycle passengers, divided in those having brought 1-2 times and multiple times. In accordance with the regression model are the percentage saying "No" smaller, around 20 percent than for the total analysis, 50 percent can be seen in Figure 4.8. The share of "No" answers was rather similar between these two figures while the share for how the possibility would be used differed somewhat, only slightly higher for those having brought a bicycle occasionally. People having brought a bicycle multiple times were more inclined to answer that they would use it for both commuting and recreational purposes. However, the total amount of respondents answering that they had brought a bicycle multiple times was low, 21 respondents distributed between once a month and more than three times per week, why the exact percentages may fluctuate if the sample size of the specific group would increase.

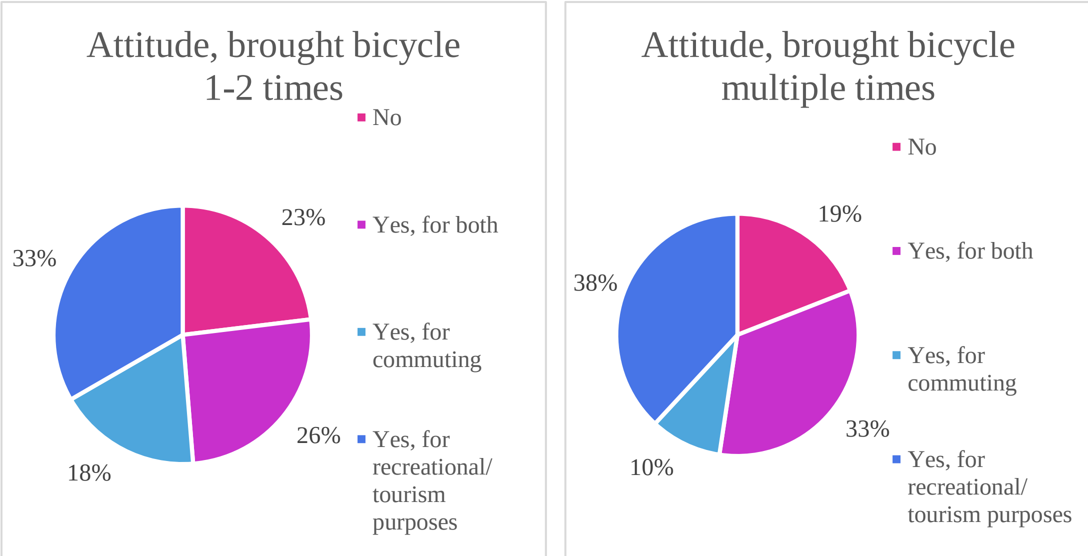


Figure 4.18 Attitude for respondents having brought a bicycle on board a train once or twice the last year to the left and multiple times to the right.

Important to remember is how the outcome question was formulated; “Would you bring the bicycle on board the train more if the possibilities were improved?”, with emphasis on *more* and *improved*. Consequently, if a person already utilises the possibility to a large extent is the probability for using it more not as high. However, the results show that not many carry a bicycle on board extensively, which is why it could be argued that it does not influence the results significantly.

The distribution for the three city regions in terms of “Yes” and “No” in whether respondents would bring a bicycle more are shown in Figure 4.19. All alternatives containing yes are merged, i.e. the figure is not separating different use applications. As can be seen people in Skåne region have a 50/50 distribution while for Gothenburg/Västra Götaland there is a difference of approximately ten percent which is also applicable for Stockholm region. However, Skåne region has worked more with the possibility through different MM measures and campaigns, see Section *3.2.1.3. Region Skåne: Malmö* and Section *3.3.4. Examples of Soft Measures*, which could partly explain the higher positive attitude.

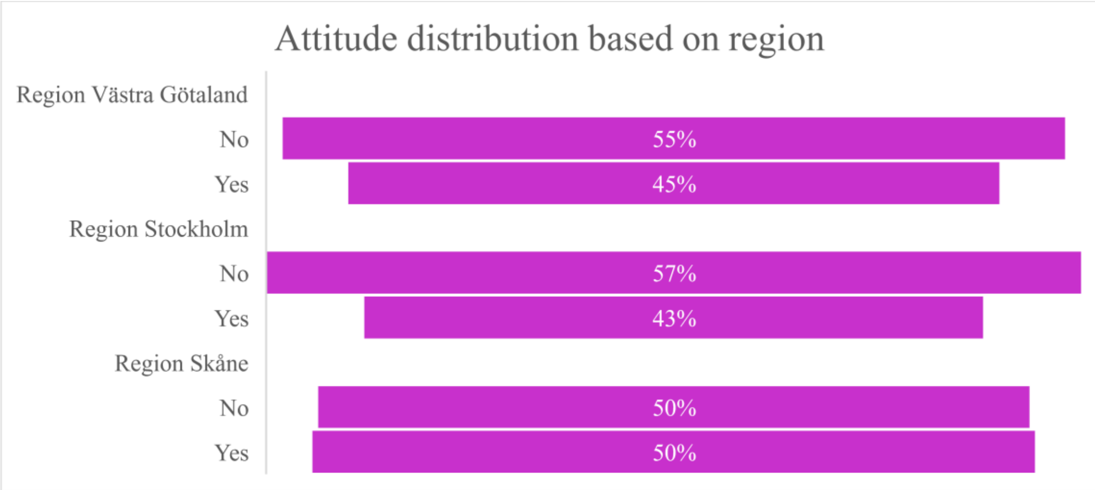


Figure 4.19 Attitude depending on region.

The age distribution of those who have a negative attitude in comparison to those who have a positive attitude is somewhat similar. The positive answers specified to commuting, recreational or both were put into one category, “Yes”. The results are presented in Figure 4.20 below. The trend that could be interpreted from the graphs is that younger people have a higher tendency to have a positive attitude towards bringing bicycles on board trains. Only 20-29 have a majority for answering “Yes”. The attitude of for example 40-49 was worse in this analysis with all answers compared to the binomial logistic regression model where 40-49 were declared as inclined to a positive attitude.

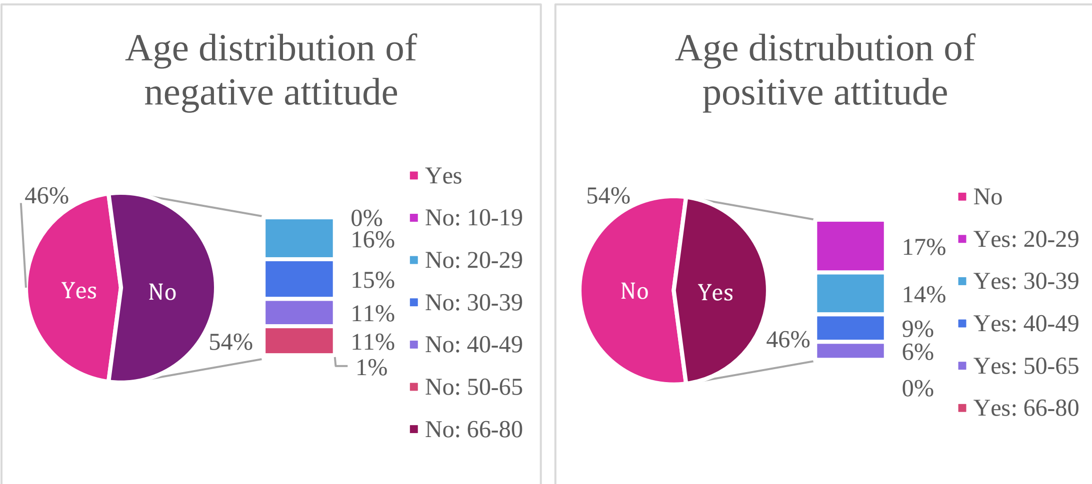


Figure 4.20 Distribution of age for negative attitude to the left and positive attitude to the right.

5 Discussion

The following chapter discusses the topics brought up in this thesis. Furthermore, a package of measures for the Gothenburg region with regards to previously mentioned examples and other aspects from the literature study is presented according to prior information and personal thoughts.

5.1 Hard measures

Hard, technical measures can be implemented for different purposes. In a point of view where the most important travel mode is the bicycle and the finances for a project is a non-issue, it is obvious that specific bicycle carriages should be implemented and that bicycles should have the highest priority. However, this is not what the Swedish society currently looks like. Many people prefer other modes, some of which like bicycle are sustainable such as walking or public transport. It is not preferable to change the behaviour of those already choosing sustainable modes, but rather those who are not. People that are using sustainable travel modes should have the same ability as today if the possibility to bring bicycles on board trains is improved. Since a bicycle is space demanding, the implementation needs to be balanced to the compromises of other passengers. Additionally, not everyone is able to travel by bicycle, and to get a sustainable society, all people must be included in the plans. Therefore, it could be argued that shared space with possibility to secure bicycles is most suited for the Gothenburg region.

However, some measures that facilitate for cycle passengers also ease the trip for others. For example, the less physical barriers existing on platforms and entrances to a train, the better it gets for both cycle and wheelchair passengers. Therefore, low floor is recommended, to avoid fold out ramps which limit accessibility. To ensure that other passengers are as little negatively affected as possible, the hand-held option is not recommended. Fixation devices should be present as the specific trains often reach high speed and the bicycles could be a safety issue if not secured. These solutions should also have clear signs of how to use them in order to increase the chance of their usage.

Regarding what is the optimal solution for bicycles on trains based on the examples presented in Section *3.1.3. Examples of Hard Measures*, there are some different angles. The first example on Caltrain only allows two bicycles in each bicycle area with a fixation device that is hard to use, this option is therefore not optimal. Foldable seats with bicycle stands underneath instead of permanent seats for passengers allow passenger seating areas while not limiting the space for standing or cycle passengers much. It is therefore the best solution to have a bicycle carriage with foldable seats on both sides of the carriage. This is preferred over the option of having foldable seats with bicycle stands on one side and permanent, non-foldable seats on the other side. This option of permanent seats could be better suited for longer train journeys where commutes do not normally imply, since permanent seats may be preferred over foldable for seated passengers. However, foldable seats might be an acceptable downgrade for shorter train commutes. Foldable seats also allow better room for exit and entrance to the train, minimising security risks. The last option of hooks to fixate the bicycle standing vertically against the wall offers a lot of space, yet may this solution be hard to use properly. For smaller bicycles, this fixation device might not even be possible at all. This option could however be good for a dedicated bicycle carriage for long distance trains, where entrance and exit of bicycles is less frequent. It could be better suited for reservations of a bicycle spot, for trains that require seat booking for all passengers.

Except from considering the thoughts explained above, train operators and decision makers need to weigh in cost and time. It is both expensive and time consuming to obtain new trains or refurbish existing ones, and they should match the overall demand of all passengers. Unless the demand for bringing bicycles on board is high, there is no reason for decision makers to exaggerate dedicated bicycle spaces that may not be used.

5.2 Different Cities

All cities have different starting points and consequently require different approaches. One common factor for all investigated cities is safety, that is always mentioned as a key factor in all cases, regarding platform and emergency exits.

There are differences in the approach as to priority of bicycles in comparison to allowing more passengers. The focus could be put on either bicycle sharing or personally owned bicycle. All the cities and countries except Denmark are choosing to focus more on bicycle parking facilities in connection to public transport hubs, as well as to expand or introduce sharing systems for bicycles. They argue that the capacity is lost and have to many security issues regarding bicycles on trains. However, Copenhagen does not report any of these issues even though the extent of bicycles being carried on board is the highest in that region. It could come down to the cyclist's attitude and how much prone that are to following rules. The survey done 2009 compared to the survey done for this thesis showed that the people in Skåne generally have a better attitude towards bicycles on trains, which could be due to the proximity of Skåne to Copenhagen and Denmark. The interest to investigate possibilities of increased bicycle share on trains is high from the regions' point of view even though the priority lies in other areas. Västtrafik is interested in investigating the possibility as the interest is high from both political views and from the society to expand all solutions connected to public transport and bicycles. Nevertheless, there must be a clear desire from the public to specifically improve in the possibility to carry bicycle on board for Västtrafik to invest in it.

One thing that both responsible people in Gothenburg and Stockholm mentioned was the lack of knowledge about the demand for bicycles on trains. It is hard to know how many people that use the possibility since there is no extra bicycle tickets required. They were therefore very unsure when asked about how much the capacity is used up, and both commented on how that would be favourable to investigate further. The problem however lies with how that measurement is to be taken. One alternative is the train conductors noting an approximate of the usage, but the exact number is hard to determine since passengers can get off and on at each station. Because of this lack of measurements, Västtrafik had difficulties following up their decision to allow bicycles as they could not see the improvement the measure brought. It should be strived to gain knowledge of if making the possibility free charge has resulted in an increase and hence if this should be the goal for all of Sweden.

5.3 Soft Measures

A challenge with soft measures is the relatively new application in the transport field. These measures depend highly on circumstances, which are not easily controlled or cannot be altered in a transport environment. Furthermore, although many studies report that soft measures such as Mobility Management and Nudging increase the effectiveness of technical measures, there are few studies investigating success in terms of numbers. When certain measures do not have evidence of effectiveness, it may be hard to gain resources for implementation of them. On the other hand, soft measures are often claimed to be cost efficient why it should be relatively easy to invest in, to some extent. However, there is a necessity of knowledge about the measures and a will to implement for the transformation to happen. Additionally, it is important to not only copy a soft measure that worked somewhere else and expect the same result, but to customise them to make them most effective for the specific case. Since information about effectiveness is lacking, documentation of evidence together with the specific circumstances must be standard for those implementing soft measures. Through that, many more can take advantage of the benefits from MM and Nudging.

Informational and promotional measures are the main categories within Mobility Management which can be applied for personal transport. To ensure that people know about a certain possibility, information must be spread, and promotional measures can help doing that. Site-based measures a restrained to a location, which in this thesis' case may be at stations in Region Västra Götaland and possibly also in public transport connection points within the city. To use and take advantage of supportive and integrating measures is a good way to further make the situation more effective.

To consider human behaviour when designing infrastructure cannot be other than beneficial as people's behaviour control the use of hard measures. However, it must be ensured that nudges are used correctly and transparently, while not exaggerating the openness since the effectiveness then is proven to be less. Recommended alternatives for personal transport are to use social norms and loss aversion in customised travel information.

Campaigns may be performed if the desire is to emphasise a solution, especially during a large change in infrastructure and the awareness and curiousness is enhanced. However, the demand of resources is very high both when designing and performing a campaign. A much less demanding solution is to implement an option of bicycle combination in a travel planner. It is relatively cheap and easy to present the possibility and simplifies for cycle passengers, which probably would increase the use of the bicycle-train system. A preferable design of the solution is to implement different types of combinations and to clearly state which departures that allow bicycles on board.

To present information clearly on the stations is important, if not necessary to help people follow rules and regulations. Additionally, it is essential to know which departures that allow bicycles. Additionally, information on which carriage that have cycle spaces must be provided, and where that location is to facilitate for both cyclists and other passengers. It can be done in different ways, either very clearly marked on carriages and platforms or presented in the display where the carriage order is shown.

5.4 Survey

The survey was selectively distributed on a few different platforms. Therefore, the types of people responding to the survey depend on the chosen platforms. Furthermore, since it was web-based was a certain skill of computer technique required, possibly why there was only ten respondents over 65 years. If the survey was to be distributed in paper form as well, maybe there would have been more people over 65 responding. Additionally, the majority of the respondents were within the age span on 20-29, which could be explained by the use of social media where the survey was spread and the fact that it was done as educational work. This is not representative of the total Swedish population, which has to be regarded when analysing the results. A greater sample size often has a better representation of reality, if all different groups are represented. In this survey, the total amount of answers was large but specific interest groups were smaller. As mentioned, is a large sample size most often preferable to increase the reliability of a survey, which was true for the full survey however the most interesting group of responders, i.e. the train commuters were a smaller group.

The design and wording of the questions can also have a large effect on the answers. In hindsight, some aspects would have been altered if performed again. The survey was for example first adapted for Region Västra Götaland, but then altered to include the regions of Stockholm and Skåne. Therefore, the questions were most adapted to the conditions in Region Västra Götaland, and some aspects were then not considered. For instance, many respondents stating that they travel within the city but with train do probably use the metro system, which was not intended to be classified as train in this survey. This should have been clearly stated but was overlooked as in Sweden is the metro system only present in Stockholm. Another aspect is that some respondents use train and bicycle in periods, perhaps using mainly bicycle in the summer months but train in the winter. This could have been specified as it could be difficult for those concerned to answer the frequency use for instance.

Furthermore, a definition of “commuting” could have been included, as some respondents may not have considered themselves as commuting but still be relevant for this survey. The definition is in itself not explicit in time or distance, but it could have been facilitating for this study to have defined it in the survey. For example, some respondents also interpreted the question in a way that was not intended, that “commuting” could be travelling from Gothenburg to Stockholm once a week.

For the travel mode before and after the train trip segment, is was believed that setting a distance range would be interesting. It was set for bicycle and car, as it was thought to not be as interesting for the other modes. However, it would have been good for the binomial logit model, which was not known at the time of designing the survey. It was discussed if time would be a relevant measure instead of distance, yet it was concluded that the two modes would not be comparable then. For instance, ten minutes by bicycle may be much shorter than ten minutes by car depending on the urban infrastructure, and no conclusions could be made from that. Therefore, distance was chosen as a measurement. The distance of two kilometres was chosen, argued to be a reasonable distance that people are willing to cycle. The Swedish average distance is reported to be four kilometres as described in Section *3.2.1.2. Region Stockholm*, and three kilometres was stated in Section *3.3.1. Transportation modes* to often be faster to cycle than car. The distance two kilometres was chosen since the bicycle trip is only a segment of the whole trip. Furthermore, it was discussed that people going by car shorter than two kilometres would be potential cyclists for that trip segment, yet it was only five respondents who stated to be taking the car such a short distance before the train segment and none after.

The matter of respondents not following the guidelines of the questions, or not thoroughly reading each question, affected the overall outcome of the survey. For some answers it was obvious that the respondents had clicked wrong by mistake or not read the question thoroughly. Another source of error was in regard to the number of alternatives the respondents could choose. Two of the questions were set up as allowing the responder to choose maximum of two alternatives, as opposed to only one alternative which the default is. This was specified in the wording of the questions; however, the online platform did only allow the option of allowing multiple alternatives, consequently the respondents could choose more than two alternatives. For the aspired outcome more than one alternative was desirable, hence the setting. However, several respondents choose three, four or five alternatives resulting in unreliable data for those questions.

5.5 Binomial Logistic Regression Model

When setting up the logit model, it was desired to use the survey responses in the greatest extent possible. However, the survey was not designed to be used in a regression model based on the types of answers made possible, which is why many assumptions needed to be made. An example is the two distance variables, where only bicycle and car had the specified distance. After that walking was assumed to be shorter than two kilometres and public transport as longer. However, partly from own experiences, it is likely that many that use public transport also do so for trips shorter than two kilometres – especially when it is only a part of the trip. If the thesis would be performed again with the same methodology, then the answers should have been more adapted for a logit model approach.

The total survey had a rather large sample size with 608 answers. However, only 194 of the responses could be used for the binomial logit model. The reliability decreases with sample size, but the largest source of error was probably the fact that the answers did not fit that of a logit model very well. That resulted in a model that was not very well suited, as the many assumptions developed uncertainties. SPSS provide a variety of tests that firstly are hard to interpret for beginners in statistics and secondly only implying a range of certainty of the model. The threshold value of 0.95 is standard, but if the sig.-value is deviating it does not necessarily mean that the model is insignificant, but just not as good as preferable. One of the most uncertain variables was "Commuting within or outside/over city borders". If this was to be excluded, the sig.-value for the total model was within the threshold and this model may have been more relevant. However, the accuracy of percentages for correct predictions of not might not improve, which is why it the model was kept with all variables.

The model used the default boundary of statistical significance of 95 percent, a commonly used boundary. However, it does not have to be the only accepted boundary. The higher boundary for statistical significance that the model reaches within, the better the model, but a model outside of that could still be an acceptable model. For the used model in this thesis, some threshold values ended up outside of the pre-set 95 percent significance interval, but it lies within a 90 percent interval. In those cases, it was argued that the model was not a good fit as it did not reach the threshold value. In is fact the model just not a perfect fit, but still a good fit.

According to the binomial logit model in SPSS, there was only one variable that was statistically significant; if respondents had brought a bicycle on board before. These were more likely bring the bicycle *more* than at the time of the survey, if the circumstances were improved. The other variables did not fit the model as good, and none were statistically significant with the used threshold. However, some if the tests did imply that the model was a good fit, at the same time as showing around only 60 percent accuracy of the outcome. Hence, since the various tests specify different things, the results were somewhat contradictory. Probably is the model not as fitting because of the assumptions made to get there, why more time would be needed to both adjust the model to create variables and parameters that are suiting as well as for interpreting the model. Due to the limitation in time was the model used as it was, to enable the other parts of the thesis. Therefore, the results from the binomial model should be used with caution.

The logit model suggested that longer distances, for both the distance to and from the stations, implies a higher probability. This could be because the bicycle is more necessary and beneficial for longer distances whereas shorter distances instead are more flexible when done by walking. The bicycle use could also depend on lack of public transport infrastructure combined with a long distance to or from the train station. Furthermore, the binomial analysis of the survey implied that both 20-29 years olds as well as 40-49 had higher probability do bring their bicycle more, perhaps since many in the age 30-39 have small children and either find it troublesome or need to carry a stroller instead. People aged 50-65 could have the lowest probability because they find physical exercise more exhausting and have more deep-rooted behaviour. Younger people have another view of owning a car and have not used their travel behaviour as long why it is easier to alter, and they are generally more open to change. However, a small trend could be seen from the calculations in that the age difference was more important for people reporting that they would not carry the bicycle on board more, versus to those stating that they would. In conclusion, it is more important to direct measures specific to age groups when aiming to get people to try out the possibility, possibly through campaigns, than when continuously informing and promoting. Furthermore, the age spans 20-29 and 40-49 are generally easier to nudge, while people aged 30-39 and over 50 need more effort.

5.6 Total Data Analysis

From the binomial logit model in SPSS, it was seen that respondents that had brought a bicycle within the last year was more inclined to increase the usage if circumstances for bicycles on board would be improved. Thus, this group was analysed further in the total data analysis. This group was however very small, 60 in total and 21 responded more than three times. Even though the characteristics of this group was deemed interesting, it would have been more representative with a larger sample size.

Regarding the reasons for having brought a bicycle on board a train or not, the respondents could only choose one. Many respondents reported a lack of interest and that they rarely use the train, and they would be harder to affect. The other alternatives, roughly 150 answers, were reasons able to improve easier with means from different decision makers. Almost ten percent of the total sample size stated that unclear rules and regulations or that the possibility was not known was the main reason for not having brought a bicycle on board. Mobility Management and Nudging could easily improve the circumstances for these respondents and those with the same knowledge level. Over ten percent reported the importance of lack of room as well as uncertainty of room to be the highest. Some respondents do consequently believe that the possibility should be expanded. One solution could be to implement a reservation system for bicycle spaces, possibly to a smaller cost and where dedicated spaces exist. A smaller portion of respondents reported the cost to be too high. However, for Region Västra Götaland it has been free of charge since 2018 yet may information and promotion not have reached all potential passengers.

Lastly, an important finding was that even though only ten percent of the respondents in Region Västra Götaland had brought a bicycle within the last year, 45 percent reported an interest of carrying a bicycle on board more if the circumstances were improved. This percentage does probably not include respondents that regularly bring bicycles due to the wording of the question; frequent users probably would not bring a bicycle more than they currently do. The conclusion that it is even more than 45 percent that would carry bicycles can therefore be drawn, assuming the sample size is representative for the population. Hence, according to the survey there is a desire from inhabitants in Region Västra Götaland to increase the possibilities regarding carrying bicycles on trains around Gothenburg.

5.7 Package of Measures for Region Västra Götaland

The goal of this study was to bring forward measures that was believed to fit the best for Gothenburg and Västra Götaland. As has been mentioned in several locations, soft measures increase the effectiveness of hard measures and soft measures are often most effective when implemented together with other measures. Hence, this section will conclude in a package of measures, containing combinations of soft and hard measures. These measures are previously mentioned in the report, or with smaller modifications to fit the specific case. The ideal situation is where all measures are implemented, however some may be suited to cities and environments with a certain modal share or size. Therefore, the measures mentioned below are optimised to be good enough and not too expensive or extensive for the current Gothenburg situation and demand.

Firstly, it is therefore recommended to at least follow the proposed EU-guidelines of offering eight places for bicycles. However, these places do not as a start need to be only dedicated bicycle spaces, but shared spaces would be sufficient with fixation devices. The recommended spaces are argued for under Section *5.1. Hard measures*, with the final recommendation being shared spaces with foldable seats over bicycle stands with fixation devices and priority for bicycles. When bicycles have priority, there should be another dedicated space for wheelchairs and clear instructions of how the priority works displayed near the seats. Since train renovations could be complex and expensive, it is not recommended to change the interior too much on the current train sets but to consider changes more thoroughly for future procurements. For future train sets it is recommended to invest above the proposed EU guidelines of dedicated bicycle spaces for eight bicycles, to have dedicated spaces for an even higher capacity. The current train sets as well as the possible new ones should have clear markings on the carriages that allow bicycles. The same clearness should be present inside the trains with markings of bicycle spaces and information of how to fasten the bicycles.

To further facilitate for cycle passengers and not have unnecessary obstacles to bring a bicycle, the accessibility to the platform should be ensured through either elevator or bicycle ramp in the stairway if there is a height difference to access the platform. At the stations should information regarding bicycles on board be clearly and visibly stated. If possible, for example if specific trains always depart from the same platform, markings should be present either at the ground or with a sign. If this measure is not possible, the bicycle carriage location could be presented in the display at the platform informing about the departure, carriage order etc. Possibly could both measures be implemented to ensure clear information for everyone. This kind of measure does not require a lot of effort if the information exist, while still making the situation better for cyclists.

Outside the station, by cycle paths, an easy measure to implement is real time signs with information of departures for commuting trains such as DRIPs, similarly to those existing outside Gothenburg for commuting car parking lots. To offer this solution also for cyclists require some means, but not extensive material or too expensive. It is recommended from the literature study that this information is provided for all departures within three kilometres from larger stations within the region. The logit model implicated that people with distances over two kilometres to or from the station are more prone to bring their bicycle. It is therefore recommended to have signage towards the stations starting from further than three kilometres. This measure facilitates the planning while cycling. Before the trip, many people use the smart phone app Reseplaneraren, the travel planner app in Västra Götaland for alternatives with public transport. Bicycles should be included in Reseplaneraren where a choice of different possibilities with bicycle easily can be made, such as the well-used app in Malmö. It is relatively easy implemented without being expensive and still helping both existing cycle passengers and promoting the possibility to others. Important to remember is to include which departure, if not all, that allow bicycles.

Other measures that could be done in order to make people interested in and aware of the opportunity is to launch campaigns. Specific campaigns for bicycles on trains could be to launch campaigns for people to try the possibility to borrow a bicycle to bring on board during a certain time period, similar to the campaign in Section *3.3.4.1.4 Buss Ohoj!*, but directed to bicycle use on trains. Parts of the mentioned campaigns in this thesis could be modified to fit bicycles on trains, such as in Section *3.3.4.1.1 Information rings* regarding health benefits, real weather conditions and money savings. However, since the Västtrafik stated that they are not investing in this possibility as much as combining with bicycle sharing services, these extensive campaigns are not recommended until the focus is on expanding and increasing the opportunity.

As this thesis focus on the bicycle-train system mainly for commuters, the recommendations are specifically for commuting trains. However, the survey showed a large potential for recreational or tourism cycle passengers. Since one of the issues with bicycles on board trains is the potential space problem in rush hours, it could be argued that extending the possibility outside rush hours do not cause such a large space issue. To open up the possibility to become a cycling society, like Copenhagen or Amsterdam, a start could be to offer good possibilities for bicycles on board outside rush hours. For instance, it be promoted that the opportunity to bring a bicycle on the trains in Region Västra Götaland (that offer the possibility) is free of charge and the various destinations and activities that can be made with the bicycle-train system. This measure should be evaluated with measured increase and change of attitude, so that in the long run Region Västra Götaland would have basic data for the region about prospects for the future. If it is shown in a decade that the demand for bicycles on board is high, the reason to expand even for the remainder of time has a decision basis with higher certainty to be utilised. To be an attractive region also in the future, the sustainable multimodal bicycle-train system should be present more or less - more in the future.

When Mobility Management and Nudging have been implemented, there should also be a follow-up stating the circumstances and expected increase compared to the real. This in order to help the overall development of implementing soft measures as complement to hard, and to give a wider data basis to effectiveness of soft measures. As to this thesis' case, no soft measures specifically for bicycle on trains could be found.

The implementation of the measures could be of varying ease to implement. There are several separate actors that control the different areas around the trains, stations and bicycle paths. The public transport in different regions are controlled by the regions, i.e. politics control decisions. Regarding the bicycle paths, they are municipally or stately owned and consequently depend on political decisions for signage and other measures. The stations on the other hand are owned by either Västtrafik if smaller, but larger stations such as Gothenburg station is owned and administered by Jernhusen. Political decisions could be long processes, hence the measures on or around bicycle paths could take long time. The markings on the trains on the platform and train could be implemented faster if the will is present from the owners. Consequently, all stakeholders must have a common goal and be willing to invest in a measure to ensure a good outcome. The municipal responsibility is divided between several different municipals in the Region Västra Götaland that all have individual agendas and priorities. However, all municipalities are important, not only the large cities, as the concept of bringing bicycles on trains is used most by those living in suburbs to larger cities or smaller cities nearby. In order to be able to formulate a coherent plan if interesting, the region and Västtrafik could form a group with all the affected municipals and stakeholders to see the interest from their side and to be able to build a symbiotic system over the region.

5.8 Additional Thoughts

Around half of the respondents of the survey indicated a positive attitude towards bringing a bicycle on boards either for commuting or recreational purposes. However, this was not corresponding to the number of respondents that stated they had previously brought a bicycle on board. Even though the question was worded if the respondent would use the possibility more if the conditions were to be improved. There might be a difference in people's actual behaviour and the ideal behaviour that they aspire. People are in general not prone to changing habits or behaviours even though they might like the possibility. Furthermore, the survey for this thesis was very concentrated on people already using train, a sustainable mode, and their attitudes and probabilities. For another survey and analysis related to this, it would be interesting to focus on those not using sustainable modes, in order to gain knowledge about potential shift from unsustainable to sustainable modes for commuters.

Information and promotion such as campaigning are all great measures to try and change the behaviour and opportunities. However, the thoughts of the employees on board need to be considered also. As mentioned, there were some bus drivers opposing the idea of foldable bicycles on board buses. As for the trains the conductor will play a similar role. The conductor’s attitude may therefore affect the cyclists’ ability or attitude to bring a bicycle on the train. As mentioned earlier there should be an ongoing discussion with the conductors for each of the operators to discover flaws in the setup. Information regarding capacity and priority should also be made clear in order for the conductors to make firm decisions.

The aim of the binomial logit model was to obtain focus groups, most easily the importance of age and gender but also others. The significance of the model affects the importance of the results, but according to the model was the age group 20-29 most inclined to have a positive attitude of the age groups. This group was also the largest, why is could be argued that it is more significant. The smaller age group 40-49 was the second most inclined to have a positive attitude. However, this group was smaller and hence not as significant. In terms of gender did the model in SPSS imply that it was not of great importance. Furthermore, the variable in the model was one if the least statistically significant, why gender was not presented as a focus group. Due to the time limit, there was no analysis of correlation between age and gender. It may have given a more specific group, perhaps women in the age of 20-29. The focus groups could further be used to direct mainly soft measures to increase the effectiveness even more. For instance, campaigns regarding the bicycle-train system could be spread online where more young people are present instead of flyers, in newspapers or via mail.

The opportunity to carry bicycles on trains and public transport in general could be expanded to create a larger capacity. However, the demand and usage of this depends largely on bicycles being able to reach the trains. This refers to of course the accessibility issue discussed in this thesis, but it also refers to the availability of sufficient bicycle infrastructure around the stations. The analysis of connections of the bicycle infrastructure to the public transport hubs was not considered in the scope of this thesis, it was therefore assumed that the infrastructure was sufficient. Another limitation regarding possibilities to expand bicycle capacity on trains is the limited train capacity overall. The train rails have a given maximum capacity and if that is reached, more rail need to be built which is very expensive in comparison to for example building car roads. This limits the amount of extra train departures that could be added if the demand is increased.

Lastly, the question remains if these proposed recommendations will change in the future or if they will stay applicable in Region Västra Götaland. The construction of Västlänken in Gothenburg will change the train infrastructure in Gothenburg significantly. The introduction of underground stations in Gothenburg will present the security issues presented in example cities with metro. This could however be evaded as much as possible if the stations are built with bicycles in mind, information regarding this was however lacking.

6 Conclusion

In Section *5.7. Package of measures*, a solution for Region Västra Götaland is presented and discussed. It is recommended that shared spaces with foldable seats should be utilised, before allowing a higher bicycle capacity when procuring new train sets. The number of spaces should be at least eight per train set, in line with the EU proposition, with priority for bicycles as other spaces should be present for wheelchairs. Information of rules and regulations at the stations should be presented clearly to minimise security hazards. This is done by informing which carriages that allow bicycles and where to stand on the platform. Furthermore, the access to and from platforms should be ensured with stairway ramps or elevators and informed about. Information before stations should be done by implementing bicycle as an option in the travel planner, and by implementing smart signs with real time information along the path to the station.

The information and data gathered from the survey was helpful in realising what type of information is required and the characteristics of the people willing to use their bicycle on the trains more in the future. It was concluded that younger people are more prone to increase the carrying of bicycles why they may be focus groups for soft measures. Furthermore, the variable influencing the outcome the most was if the respondent had tried the possibility before. Therefore, measures to get people to try should be of priority. However, the conclusions of the binomial logistic regression model might have been of more use if the setup of the model was done differently.

The lack of effectiveness evidence is a large problem, not only for this thesis but also for companies working with implementing soft measures. Therefore, further studies should investigate different types of soft measures and their range of effectiveness to improve the choices. It is also recommended to introduce measurement procedures in projects where MM and Nudging are implemented. Other recommended further studies are to evaluate the capacity on the current trains, and for operators to investigate how the current capacity is used up in order to clarify the demand. Moreover, specific measures could be evaluated to bring forward the most efficient and effective ones for stands on board train, information on stations and information around them.

The opportunity of carrying bicycles on board trains in the purpose of commuting is, in the current situation with attitudes and limitations, not possible for a larger share of people as the capacity is low in Region Västra Götaland. However, the potential for cycle passengers outside rush hours is higher, which also could be an indication for future extensions for the bicycle-train system in Region Västra Götaland.

References

Af Frits Bredal. (2012). Ekstra plads til cykler i S-toget - Cyklistforbundet. Retrieved April 2, 2019, from https://www.cyklistforbundet.dk/Aktuelt/Nyt/Nyheder/Ekstra-plads-til-cykler-i-toget

Brög, W., Erl, E., Ker, I., Ryle, J., & Wall, R. (2009). Evaluation of voluntary travel behaviour change: Experiences from three continents. *Transport Policy*, *16*(6), 281–292. https://doi.org/10.1016/J.TRANPOL.2009.10.003

Cerny, J., & Daggers, T. (2016). *Study Bicycles on Board*. Retrieved from https://civitas.eu/sites/default/files/bikes_on_board_2move2_di7.02.03.pdf

Chatterjee, K. (2009). A comparative evaluation of large-scale personal travel planning projects in England. *Transport Policy*, *16*(6), 293–305. https://doi.org/10.1016/J.TRANPOL.2009.10.004

City of Copenhagen. (2016). Copenhagen city of cyclists. Retrieved from https://kk.sites.itera.dk/apps/kk_pub2/index.asp?mode=detalje&id=1698

Civitas. (2009). SMILE | CIVITAS. Retrieved March 27, 2019, from https://civitas.eu/content/smile

de Dios Ortúzar, J., & Willumsen, L. G. (2001). *Modelling Transport, Third Edition* (3rd ed.). Chichester, West Sussex: John Wiley & Sons.

DSB. (n.d.-a). Cykel i S-tog - Tag den med kvit og frit. Retrieved April 2, 2019, from https://www.dsb.dk/find-produkter-og-services/cykelbillet/cykel-i-s-tog/

DSB. (n.d.-b). Gode råd, når du bruger cykelvognen. Retrieved April 2, 2019, from https://www.dsb.dk/find-produkter-og-services/cykelbillet/cykel-i-s-tog/cykelvogn-i-s-tog/

DSB. (n.d.-c). Kort og billetter til cykler - tag cyklen med i toget. Retrieved March 30, 2019, from https://www.dsb.dk/rejsende/cykler/

ECF. (2017). Smarter Cycling Series: City of Copenhagen introduces variable message signs – exclusively for cyclists | ECF. Retrieved April 9, 2019, from https://ecf.com/news-and-events/news/smarter-cycling-series-city-copenhagen-introduces-variable-message-signs-–

ECF. (2018). #VisionaryCities Series: The City of Copenhagen introduces variable message signs, exclusively for cyclists II | ECF. Retrieved April 9, 2019, from https://ecf.com/news-and-events/news/visionarycities-series-city-copenhagen-introduces-variable-message-signs

Elberg Nielsen, S. A., Sand, H., Sørensen, P., Knutsson, M., Martinsson, P., Persson, E., & Wollbrant, C. (2016). *Nudging and pro-environmental behaviour*. https://doi.org/10.6027/TN2016-553

Eltis. (2015). Transport mode | Eltis. Retrieved February 6, 2019, from http://www.eltis.org/glossary/transport-mode

Envall, P., Backelin, D., & Koucky, M. (2011). *Carriage of cycles on board trains: Opportunities and difficulties* (1st ed.). Trafikverket.

EPOMM. (2013). *Mobility management: The smart way to sustainable mobility in European countries, regions and cities*. (R. Thaler, Ed.) (1st ed.). Brussels: EPOMM - European Platform on Mobility Management. https://doi.org/10.1002/9781119942825.ch14

European Parliament. (2018). *P8_TA-PROV(2018)0462 Rail passengers' rights and obligations ***I*. Retrieved from http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+TA+P8-TA-2018-0462+0+DOC+PDF+V0//EN

Flamm, B. J., & Rivasplata, C. R. (2014). Public Transit Catchment Areas The Curious Case of Cycle-Transit Users. *Transportation Research Record: Journal of the Transportation Research*, *2419*, 101–108. https://doi.org/10.3141/2419-10

Forsell, L., Grahn, K., Gustafsson, N., Håkansson, M., Ljungberg, C., Neergaard, K., … Wendle, B. (2010). *Hållbart resande i praktiken*. Sveriges Kommuner och Landsting. Retrieved from www.sklkommentus.se

Gatukontoret. (2014). *Cykelbokslut 2014*. Retrieved from http://miljobarometern.malmo.se/content/docs/Cykelbokslut_2014.pdf#search='cykla+fint'

Göteborgs Stad. (n.d.). Pendelparkering - Göteborgs Stad. Retrieved February 13, 2019, from https://goteborg.se/wps/portal/start/parkeringstillstand-och-parkeringsplatser/parkera/parkeringsplats/pendelparkering/!ut/p/z1/hY5BC4IwHMU_jdf9tyXquq2DlUoaCNouobJUcE7mSujTZ8eg6N0e7_d4DwSUIMbq0beV7fVYDau_CO-akegc7AjH6Z6F-JjHWXiKk_SQUyj-AWKN8Q9xDBGIvlZoaRT

Government of the Netherlands. (n.d.). Opportunities for expanding the use of bicycles. Retrieved March 30, 2019, from https://www.government.nl/topics/bicycles/bicycle-policy-in-the-netherlands

Gris Orange Consultant. (2009). *Bike-Sharing Guide*. Transport Canada. Retrieved from www.tc.gc.ca/urban.

Hiselius, L. W., & Rosqvist, L. S. (2016). Mobility Management campaigns as part of the transition towards changing social norms on sustainable travel behavior. *Journal of Cleaner Production*, *123*, 34–41. https://doi.org/10.1016/J.JCLEPRO.2015.08.055

Holladay, D. (2002). Cycling with public transport: combined in partnership, not conflict. *Planning for Cycling*, 110–142. https://doi.org/10.1016/B978-1-85573-581-1.50012-5

HRV. (2017). *Buss ohoj! - Slutrapport 2017*. Retrieved from https://alfresco.vgregion.se/alfresco/service/vgr/storage/node/content/workspace/SpacesStore/efbe9ba9-3ed5-4157-999c-f20fb8ce433c/Slutrapport Buss ohoj 2017.pdf?a=false&guest=true

I bike CPH. (n.d.). I Bike Cph. Retrieved April 19, 2019, from https://www.ibikecph.dk/

IBM. (n.d.-a). Hosmer-Lemeshow Goodness-of-Fit Statistic (logistic regression algorithms). Retrieved May 15, 2019, from https://www.ibm.com/support/knowledgecenter/en/SSLVMB_22.0.0/com.ibm.spss.statistics.algorithms/alg_logistic_statistics_hosmer-lemeshow.htm

IBM. (n.d.-b). Omnibus Test. Retrieved April 4, 2019, from https://www.ibm.com/support/knowledgecenter/en/SSLVMB_23.0.0/spss/tutorials/genlin_ships_omnibus.html

IBM. (n.d.-c). Tests of Model Fit. Retrieved April 4, 2019, from https://www.ibm.com/support/knowledgecenter/SSLVMB_24.0.0/spss/tutorials/log_loan_fit.html#log_loan_fit

Kager, R., Bertolini, L., & Te Brömmelstroet, M. (2016). Characterisation of and reflections on the synergy of bicycles and public transport. *Transportation Research Part A: Policy and Practice*, *85*, 208–219. https://doi.org/10.1016/J.TRA.2016.01.015

Kollektivtrafiksekretariatet. (2013). *Målbild Tåg 2035*. *VGR*. Retrieved from www.vgregion.se/malbildtag2035

Küster, F., Lancaster, E., & Tusl, M. (2016). Bikes and Trains: 7 Basic Services that give Cyclists a Smile, 1–18. Retrieved from www.ecf.com

Lindahl, T., & Stikvoort, B. (2015). *Nudging - det nya svarta inom miljöpolicy?* (1st ed.). Falun: Fores. Retrieved from www.fores.se.

Lindholm, S. (2016). *Nudging och mobility management för mer hållbart resande: Finns kopplingar och komplement?* Retrieved from http://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=8877656&fileOId=8877659

Liu, X. C., Porter, R. J., Zlatkovic, M., Fayyaz, K., & Taylor, J. (2018). *First and Last Mile Assessment for Transit Systems*. Retrieved from https://www.ugpti.org/resources/reports/downloads/mpc18-347.pdf

Liu, Z., Jia, X., & Cheng, W. (2012). Solving the Last Mile Problem: Ensure the Success of Public Bicycle System in Beijing. *Procedia-Social and Behavioral Sciences*, *43*, 73–78. https://doi.org/10.1016/j.sbspro.2012.04.079

Lunn, P. (2014). *Regulatory Policy and behavioural Economics*. Paris: OECD. Retrieved from https://www.esri.ie/system/files/media/file-uploads/2015-10/BKMNEXT249.pdf

Malmö stad. (2016). Trafik- och mobilitetsplan. Retrieved from https://malmo.se/download/18.16ac037b154961d0287b3d8/1491303428445/MALM_TROMP_210x297mm_SE.pdf

Malmö stad. (2017). Cykelåret 2017 Malmö. Retrieved from https://malmo.se/download/18.5c6f59e616436ac201f19a3f/1534492818854/cykelbokslut+2017.pdf

Marteau, T. M., Ogilvie, D., Roland, M., Suhrcke, M., & Kelly, M. P. (2011). Judging nudging: can nudging improve population health? *BMJ (Clinical Research Ed.)*, *342*, d228. https://doi.org/10.1136/bmj.d228

Mattsson, C., Sundberg, R., & Nilsson, A. (2016). *Strategi för Ökad Cykling i Västra Götaland*. Gothenburg. Retrieved from https://www2.sahlgrenska.se/upload/Regionutveckling/Infrastruktur-IT/Cykel/REGIONAL_CYKELPLAN_slutversion_2016.pdf

MAX. (2009). *Mobility Management: a Definition*.

McClintock, H. (2002). Promoting cycling through 'soft' (non-infrastructural) measures. In *Planning for Cycling* (1st ed., pp. 36–49). Cambridge: Woodhead Publishing. https://doi.org/10.1016/B978-1-85573-581-1.50007-1

Metro. (n.d.). About the author - Bicycle. Retrieved from https://intl.m.dk/#!/about+the+metro/tickets/bicycles

Meyer, M. D., & Miller, E. J. (2001). *Urban Transportation Planning: A Decision-Oriented Approach, Second Edition*. (E. M. Munson, Ed.) (2nd ed.). New York: McGraw-Hill.

Mont, O., Lehner, M., & Heiskanen, E. (2014). *Nudging: A Tool for Sustainable Behaviour?* Lund. Retrieved from www.naturvardsverket.se/publikationer

Mott Macdonald. (2008). *GMPTE Metrolink The Implications of the Carriage of Bicycles on Trams*. Retrieved from https://www.whatdotheyknow.com/request/28163/response/76030/attach/4/243243 AG DOC 001A Bicycles on Trams.pdf

NS. (n.d.-a). Bicycle in the train | Travel Information. Retrieved March 30, 2019, from https://www.ns.nl/en/travel-information/bikes-on-the-train.html

NS. (n.d.-b). Bicycle ticket off-peak | Individual tickets. Retrieved March 30, 2019, from https://www.ns.nl/producten/en/onbeperkt-reizen/p/fietskaart-dal

NS. (n.d.-c). Customer Service.

NS. (n.d.-d). OV-fiets | Door to door. Retrieved March 30, 2019, from https://www.ns.nl/en/door-to-door/ov-fiets

NS. (2015). Explore Holland by train: About travelling, tickets and prices. Retrieved from https://www.holland.com/global/tourism/plan-your-holiday/getting-around-in-holland/public-transport/travel-by-train.htm

Örstadius, K. (2008, July 10). Kampanj mot löjliga bilresor. *Kristianstadsbladet*. Retrieved from http://www.kristianstadsbladet.se/kristianstad/kampanj-mot-lojliga-bilresor/

Ortmann, A., & Dixit, V. (2017). *Nudging Towards A More Efficient Transportation System: A Review of Non-pricing (Behavioural) Interventions*. Retrieved from http://infrastructurevictoria.com.au/sites/default/files/images/University of New South Wales paper - A review of non-pricing behavioural interventions - November 2017.pdf

Regeringen. Mål för framtidens resor och transporter (2009). Retrieved from https://www.regeringen.se/contentassets/80dd7d80fc64401ca08b176a475393c5/mal-for-framtidens-resor-och-transporter-prop.-20080993

Regeringskansliet. (2017). En nationell cykelstrategi för ökad och säker cykling. Retrieved from http://www.regeringen.se/498ee9/contentassets/de846550ff4d4127b43009eb285932d3/20170426_cykelstrategi_webb.pdf

ReStore. (2011a). 4.12 The SPSS Logistic Regression Output. Retrieved from http://www.restore.ac.uk/srme/www/fac/soc/wie/research-new/srme/modules/mod4/12/index.html

ReStore. (2011b). Glossary. Retrieved May 15, 2019, from http://www.restore.ac.uk/srme/www/fac/soc/wie/research-new/srme/glossary/index1695.html?selectedLetter=D#deviance-2ll

Robson, D. (2018). BBC - Capital - The neglected benefits of the commute. Retrieved February 13, 2019, from http://www.bbc.com/capital/story/20180806-the-neglected-benefits-of-the-commute

Rojas-Rueda, D., de Nazelle, A., Andersen, Z. J., Braun-Fahrländer, C., Bruha, J., Bruhova-Foltynova, H., … Nieuwenhuijsen, M. J. (2016). Health Impacts of Active Transportation in Europe. *PLOS ONE*, *11*(3), e0149990. https://doi.org/10.1371/journal.pone.0149990

SCB. (2018). Folkmängd i riket, län och kommuner 30 september 2018 och befolkningsförändringar 1 juli–30 september 2018. Totalt. Retrieved February 13, 2019, from https://www.scb.se/hitta-statistik/statistik-efter-amne/befolkning/befolkningens-sammansattning/befolkningsstatistik/pong/tabell-och-diagram/kvartals--och-halvarsstatistik--kommun-lan-och-riket/kvartal-3-2018/

Schlag, P. (2010). Nudge, Choice Architecture, and Libertarian Paternalism. *Michigan Law Review*, *108*(6). Retrieved from http://repository.law.umich.edu/mlrhttp://repository.law.umich.edu/mlr/vol108/iss6/5

Skåne Region. (2016). *Cykelstrategi för Skåne*. Retrieved from https://www.skane.se/Public/Protokoll/Regionala utvecklingsnämnden/2016-08-26/Cykelstrategi för Skåne/Cykelstrategi_för_Skåne.pdf

Skånetrafiken. (n.d.-a). Reseplaneraren Skånetrafiken. Retrieved March 30, 2019, from https://reseplaneraren.skanetrafiken.se/querypage_adv.aspx

Skånetrafiken. (n.d.-b). Ta med cykel på bussen eller tåget - köp biljetten innan du stiger på. Retrieved March 28, 2019, from https://www.skanetrafiken.se/sa-reser-du-med-oss/ombord/cykel/

SL. (2019). Cykel ombord. Retrieved March 30, 2019, from

https://sl.se/sv/info/resa/regler/cykel/
Stockholm stad. (2015). *Cykelplan*. Retrieved from https://cykla.stockholm/globalassets/cykla/dokument/cykelplan.pdf
Styr & Ställ. (2019). Information. Retrieved May 3, 2019, from http://en.goteborgbikes.se/
Svensk Cykling. (2016). *Cykeltrandrapport 2016*. Retrieved from http://svenskcykling.se/wp-content/uploads/2016/12/Cykeltrendrapport2016.pdf
Svensk Cykling. (2018). *Cykeltrendrapport 2018*. Retrieved from http://svenskcykling.se/wp-content/uploads/2018/04/Cykeltrendrapport_2018_pdf-1.pdf
Sveriges Riksdag. Lag (2015:953) om kollektivtrafikresenärers rättigheter, Pub. L. No. 2015:953 (2015). Sveriges Riksdag. Retrieved from https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/lag-2015953-om-kollektivtrafikresenarers_sfs-2015-953
Testbedstudio Arkitekter. (n.d.-a). Cykla fint! Retrieved March 27, 2019, from http://www.testbedstudio.com/cykla-fint
Testbedstudio Arkitekter. (n.d.-b). Inga löjgliga bilresor. Retrieved March 27, 2019, from http://www.testbedstudio.com/inga-ljliga-bilresor
Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving Decisions About Health, Wealth and Happiness*. New Haven & London: Caravan Book House.
Trafikverket. (2014). *Regional cykelplan*.
Trafikverket. (2015). Marknaden. Retrieved March 27, 2019, from https://www.trafikverket.se/for-dig-i-branschen/jarnvag/tagplan-att-skapa-tidtabeller-for-tag/Marknaden/
Trafikverket. (2016). *Nationellt cykelbokslut 2016*. Retrieved from https://trafikverket.ineko.se/Files/sv-SE/26970/Ineko.Product.RelatedFiles/2017_126_nationellt_cykelbokslut_2016.pdf
Trafikverket. (2017). *Nationellt cykelbokslut 2017*. Trafikverket. Retrieved from https://trafikverket.ineko.se/Files/en-US/48909/Ineko.Product.RelatedFiles/2018_166_nationellt_cykelbokslut_2017.pdf
Trafikverket. (2018a). Fyrstegsprincipen. Retrieved February 8, 2019, from https://www.trafikverket.se/for-dig-i-branschen/Planera-och-utreda/Planerings--och-analysmetoder/fyrstegsprincipen/
Trafikverket. (2018b). Kapacitet. Retrieved March 27, 2019, from https://www.trafikverket.se/for-dig-i-branschen/jarnvag/Kapacitet/
UK Department for Transport. (2011). *Creating Growth, Cutting Carbon. Making Sustainable Local Transport Happen*. London.
Västtrafik. (n.d.). Cykel på tåg och buss. Retrieved March 27, 2019, from https://www.vasttrafik.se/resa-med-oss/under-resan/cykel/
VerkeersNet. (2010). FietsDRIP's in Amsterdam Noord. Retrieved April 29, 2019, from https://www.verkeersnet.nl/fiets/3989/fietsdrips-in-amsterdam-noord/?gdpr=accept
VGR. (n.d.). Buss ohoj! Retrieved April 5, 2019, from https://www.vgregion.se/om-vgr/satsningar-och-samarbeten/hallbart-resande-vast/projekt/buss-ohoj/
VGR. (2015). Strategi för ökad cykling i västra götaland. Retrieved from https://alfresco.vgregion.se/alfresco/service/vgr/storage/node/content/workspace/SpacesStore/eda88f3e-58fe-4424-95e5-f336f7b11d89/REGIONAL_CYKELPLAN_slutversion_2016.pdf?a=false&gues

t=true
VGR. (2016). *Regionalt trafikförsörjningsprogram Västra Götaland*. Vänersborg. Retrieved from www.vgregion.se/kollektivtrafik
VGR. (2017). Uppföljning av trafikförsörjnings- programmet 2017. Retrieved from https://alfresco.vgregion.se/alfresco/service/vgr/storage/node/content/workspace/SpacesStore/005e1887-e996-4ca1-a7d8-575f06809231/TFPuppfölj_2017_ny.pdf?a=false&guest=true
Visitcopenhagen. (n.d.). What are you allowed to bring on public transportation? Retrieved March 30, 2019, from https://www.visitcopenhagen.com/copenhagen/transportation/what-are-you-allowed-bring-public-transportation
Williams, T., & Brömmelstroet, M. Te. (2017). *COMBINING THE POWER OF BICYCLE USE AND PUBLIC TRANSPORT: IMPLEMENTING THE BIKE-TRAIN SYSTEM IN THE NEW ZEALAND CONTEXT*. Retrieved from https://static1.squarespace.com/static/5591f57ee4b07952c1a4d8bd/t/58a6446fbebafb4f1d1dea48/1487291509321/Williams%2C+Tom+-+Paper+14+-+Combining+the+power+of+bicycle+use+and+public+transport+implementing+the+Bike-Train+system+in+the+New+Zealand+context.pdf

Appendix I – Original Survey in Swedish

1. **Arbetar, studerar eller bor du i Västra Götalandsregionen, Region Stockholm eller Region Skåne?**
   - o Västra Götalandsregionen
   - o Region Stockholm
   - o Region Skåne
   - o Inget av ovan

2. **Pendlar du till eller från Göteborg, Stockholm eller Malmö? Om annat, ange gärna start och slut.**
   - o Till
   - o Från
   - o Inom staden
   - o Annat [Fritext]

3. **Reser du med tåg hela eller en del av sträckan?**
   - o Ja
   - o Nej

4. **Hur många gånger i veckan använder du tåg för hela eller del(ar) av din pendlingsträcka ungefär?**
   - o Färre än 1 gång per vecka
   - o 1-2 gånger
   - o 3-5 gånger
   - o 5 eller mer

5. **Hur tar du dig oftast till tåget från hemmet?**
   - o Cykel, kortare än 2 km
   - o Cykel, längre än 2 km
   - o Bil, kortare än 2 km
   - o Bil, längre än 2 km
   - o Till fots
   - o Kollektivt (ex. buss)
   - o Annat alternativ

6. **Hur tar du dig oftast till tåget från arbetsplats/skola/daglig sysselsättning?**
   - o Cykel kortare än 2 km
   - o Cykel, längre än 2 km
   - o Bil, kortare än 2 km
   - o Bil, längre än 2 km
   - o Till fots
   - o Kollektivt (ex. buss)
   - o Annat alternativ

7. **Om/när du cyklar (inte nödvändigtvis i samband med tåg), vad är största anledningen? Max 2 svar.**
   - o Hälsosamt

- Flexibelt tidsmässigt
- Flexibelt jämfört med kollektivtrafik (ex. slipper byten)
- Miljövänligt
- Slippa trängsel
- Jag cyklar inte
- Annat [Fritext]

8. Om/när du inte cyklar, vad är största anledningen till detta? Max 2 svar.

- Stöldrisk vid arbetsplats/skola
- Stöldrisk vid stationen
- Sträckan är för lång
- Sträckan är för kort
- Jag äger ingen cykel
- Det finns ingen cykelväg/bra väg
- Jag tycker att det är för jobbigt/vill inte p.g.a. t.ex. väder och höjdskillnader
- Jag kan inte ta med cykeln hela vägen (ex. på tåget)
- Parkeringsbrist vid ankomst
- Jag cyklar alltid
- Annat [Fritext]

9. På vissa sträckor finns möjlighet att ta med cykel på tåget i mån av plats. Ungefär hur ofta under de senaste 12 månaderna har du tagit med cykeln ombord på tåget (exklusive vikcykel)?

- 1-2 gånger
- 3-11 gånger
- 1-3 gånger per månad
- 1-2 gånger per vecka
- Mer än 3 gånger per vecka
- Jag har inte tagit med cykeln det senaste året
- Jag visste inte om möjligheten och har därför inte tagit med cykel på tåg

10. Vad är den främsta anledningen till gångerna du inte tagit med cykel på tåget?

- Otydliga regler och information kring cyklar på tåg
- Kostnaden är för hög (om extra cykelbiljett krävs)
- Svårtillgängligt till eller från perrongen
- Platsbrist på tåget
- Osäkerhet om plats finns
- Stöldrisk på tåget
- Jag visste inte om möjligheten
- Jag är inte intresserad av möjligheten
- Jag tar alltid med mig cykel på tåget
- Jag åker sällan tåg
- Annat [Fritext]

11. Skulle du använda din cykel mer än i dagsläget om möjligheten att ta med cykel på tåg skulle förbättras (exempelvis genom förbättring av orsaker i föregående fråga)?

- Ja, i pendlingssyfte
- Ja, i fritidssyfte

- Ja, både och
- Nej

12. Hur definierar du dig?

- Kvinna
- Man
- Annat
- Jag vill inte svara

13. Ålder

- 10–19
- 20–29
- 30–39
- 40–49
- 50–65
- 66–80
- 80+

Appendix II – Survey Translated

1. **Is your workplace/school or home situated in Region Västra Götaland, Region Stockholm or Region Skåne?**
   - Region Västra Götaland
   - Region Stockholm
   - Region Skåne
   - No/Other

2. **Are you commuting to or from Gothenburg, Stockholm or Malmö?**
   - To
   - From
   - Within the city
   - Other

3. **Do you use train for all or a part of the commute?**
   - Yes
   - No

4. **How many times a week do you use train for all (or parts) or your commute approximately?**
   - Less than 1 time a week
   - 1-2 times
   - 3-5 times
   - 5 times or more

5. **How do you usually reach the train from your home?**
   - Bicycle, shorter than 2 km
   - Bicycle, longer than 2 km
   - Car, shorter than 2 km
   - Car, longer than 2 km
   - Walking
   - Public transport (ex. Bus)
   - Other

6. **How do you usually reach the train from your work/school?**
   - Bicycle, shorter than 2 km
   - Bicycle, longer than 2 km
   - Car, shorter than 2 km
   - Car, longer than 2 km
   - Walking
   - Public transport (ex. Bus)
   - Other

7. **If you bicycle, what is the biggest reason (max 2 options)?**
   - Health and wellbeing
   - Flexible timewise
   - Flexible in comparison to public transport, e.g. no need for transit
   - Environmentally friendly

- To avoid crowded public transport/congestion
- I don’t bicycle
- Other [Free text answer]

8. If you don’t bicycle, what it the biggest reasons for that (max 2 options)?
- Risk of theft by the workplace/school
- Risk of theft by the station
- The distance is too long
- The distance is too short
- I don’t own a bicycle
- There is no good bicycle path/good road
- I think it’s too exhausting/don’t want to because of for example weather or hills
- I can’t bring the bicycle all the way
- Shortage of parking
- I always bicycle
- Other [Free text answer]

9. On certain stretches there is a possibility to bring bicycles on the train (if space permits). Approximately how many times during the last 12 months have you taken a bicycle on board the train (not including foldable bicycles).
- 1-2 times
- 3-11 times
- 1-3 times per month
- 1-2 times per week
- More than 3 times per week
- I have not taken the bicycle on board during the last year
- I did not know about the possibility and have therefore not brought a bicycle on board

10. If you don’t take the bicycle on the train, what is the main reason?
- Unclear rules and information
- Too expensive
- Bad accessibility to or from the platform
- Lack of room on the train
- Uncertainty if there is room
- Risk of theft on the train
- I did not know about the possibility
- I’m not interested in the possibility
- I always bring my bicycle on the train
- I rarely travel by train
- Other [Free text answer]

11. If the possibility of bringing a bicycle on board trains would be improved (for example by eliminating the reasons from the previous question) would you then use your bicycle more than now?
- Yes, for commuting
- Yes, for recreational/tourism purposes
- Yes, for both

- No

12. What do you identify as?
- Woman
- Man
- Other
- Would prefer not to disclose

13. Age?
- 10–19
- 20–29
- 30–39
- 40–49
- 50–65
- 66–80
- 80+

Appendix III – Calculations of Probabilities

Clarification with numbers from Excel of calculation described in Section 4.2.2. Calculation.

Variable	1	2	3	4	5	6	7	8
Intercept	1.442	1.442	1.442	1.442	1.442	1.442	1.442	1.442
Commute	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
Frequency	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532
Distance home to station	-0.295	-0.295	-0.295	-0.295	0	0	0	0
Distance station to work/school	-0.234	-0.234	0	0	-0.234	0	-0.234	0
If brought bicycle before	-1.703	0	-1.703	0	-1.703	-1.703	0	0
Gender	0.116	0.116	0.116	0.116	0.116	0.116	0.116	0.116
Age	0.573	0.573	0.573	0.573	0.573	0.573	0.573	0.573
Utility	0.488	2.191	0.722	2.425	0.783	1.017	2.486	2.72
Probability of yes	0.620	0.899	0.673	0.919	0.686	0.734	0.923	0.938
	62.0%	**89.9%**	**67.3%**	**91.9%**	**68.6%**	**73.4%**	**92.3%**	**93.8%**

Variable	9	10	11	12	13	14	15	16
Intercept	1.442	1.442	1.442	1.442	1.442	1.442	1.442	1.442
Commute	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
Frequency	0.532	0.532	0.532	0.532	0.532	0.532	0.532	0.532
Distance home to station	-0.295	-0.295	0	0	-0.295	-0.295	0	0
Distance station to work/school	-0.234	-0.234	-0.234	0	-0.234	-0.234	-0.234	0
If brought bicycle before	-1.703	0	0	0	-1.703	0	0	0
Gender	0.116	0.116	0.116	0.116	0.116	0.116	0.116	0.116
Age	0.165	0.165	0.165	0.165	0.327	0.327	0.327	0.327
Utility	0.08	1.783	2.078	2.312	0.242	1.945	2.24	2.474
Probability of yes	0.520	0.856	0.889	0.910	0.560	0.875	0.904	0.922
	52.0%	**85.6%**	**88.9%**	**91.0%**	**56.0%**	**87.5%**	**90.4%**	**92.2%**

Variable	17	18	19	20
Intercept	1.442	1.442	1.442	1.442
Commute	0.057	0.057	0.057	0.057
Frequency	0.532	0.532	0.532	0.532
Distance home to station	-0.295	-0.295	0	0
Distance station to work/school	-0.234	-0.234	-0.234	0
If brought bicycle before	-1.703	0	0	0
Gender	0.116	0.116	0.116	0.116
Age	0	0	0	0
Utility	-0.085	1.618	1.913	2.147
Probability of yes	0.479	0.835	0.871	0.895
	47.9%	**83.5%**	**87.1%**	**89.5%**

Appendix IV – Excerpt from *Rail passengers' rights and obligations*, European Parliament

Legislative resolution on Proposal for a Regulation (European Parliament, 2018).

Amendment 13: Recital 12

> "The increasing popularity of cycling across the Union has implications for overall mobility and tourism. An increase in the use of both railways and cycling in the modal split reduces the environmental impact of transport. Therefore, railway undertakings should facilitate the combination of cycling and train journeys as much as possible, in particular they should provide sufficient bicycle stands for the carriage of assembled bicycles in areas intended for that purpose on board all types of passenger trains, including high speed, long distance, cross-border and local services. Passengers should be informed of the space available for bicycles. These requirements should apply to all railway undertakings from ... [two years after the date of entry into force of this Regulation]."

Amendment 56: Article 6 – paragraph 1

> "Passengers shall be entitled to take bicycles on board the train, including on high speed, long distance, cross-border and local services. All new or refurbished passenger trains shall at the latest by ... [two years after the date of entry into force of this Regulation] include a well indicated designated space for the carriage of assembled bicycles with a minimum of eight spaces. Railway undertakings, ticket vendors, tour operators and, where appropriate, station managers shall inform passengers at the latest when purchasing the ticket of the conditions for bicycle carriage on all services in accordance with Regulation (EU) No 454/2011."