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Identifying Strategies for Improvement of Public Transportation Services

Bachelor's Thesis - Department of Space, Earth and Environment

Authors:

Fatimah Al-Nuwab, *Global Systems Engineering*

Ragnar Bergkvist Eriksson, *Civil Engineering*

Ida Kron, *Global Systems Engineering*

Erica Larsson, *Civil Engineering*

Adam Lindberg, *Global Systems Engineering*

Frida Lindgren, *Global Systems Engineering*

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Fatimah Al-Nuwab, Ragnar Bergkvist Eriksson, Ida Kron, Erica Larsson, Adam Lindberg, Frida Lindgren

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Department of Space, Earth and Environment
Division of Physical Resource Theory
Chalmers University of Technology
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Supervisor: Reema Bera Sharma, Department of Space, Earth and Environment
Examiner: Frances Sprei, Department of Space, Earth and Environment

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Chalmers University of Technology

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Abstract

Emissions generated by the transport sector have a major impact on the environment, public health, and climate change. Promoting a shift from passenger car ownership to public transportation (PT) modes can lead to a significant decrease in greenhouse gas emissions originating from the transport sector. The study aims to identify management strategies for improving the PT service by (1) investigating the perception of consumers' importance and satisfaction with PT service attributes (2) identifying the variation in perception for service attributes across consumers with different sociodemographic and trip-related characteristics (3) investigating the gap between consumers' and service provider's perception for the current PT service. The target population of the study was travellers within the city of Gothenburg, Sweden.

The study was based on a survey and was divided into three major components. Firstly, the survey responses were analysed through revised Importance Performance Analysis (IPA), based on derived importance and stated satisfaction. The result showed that the attributes *punctuality, fare* and the *number of transfers* are the major priority areas to obtain a higher overall customer satisfaction (OCS) in PT. Secondly, the study investigated, through RIDIT ranking, whether perceptions of PT service varied across different sociodemographic characteristics. The result showed that within the characteristics; age, frequency of PT usage and income, the perceptions of satisfaction differ regarding which areas to prioritise in order to obtain a higher OCS. Lastly, the service provider's perception of the PT service was obtained through interviews and a questionnaire. The results were analysed and compared with the customers' perception in order to identify differences, where *fare* and *crowding on board* were found as two key attributes.

Overall, the present work demonstrates a comprehensive approach for identifying strategies for improvement of the PT services in the context of a large city in Sweden. The approach could be applied in larger cities of other developed and developing countries. It can be used for deriving suitable policy interventions by transport planners and policymakers to improve the existing PT services, which could encourage a higher usage of PT among commuters.

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1 Introduction

This section presents the background for the study. It further describes why it could be beneficial to study the public transportation (PT) system from a consumer-centric perspective. The section continues with presenting the aim, research questions and scope.

1.1 Background

The emission of greenhouse gases (GHGs) into the atmosphere through human activity is a major contributor to climate change and global warming (IPCC, 2018). Due to higher dependency on fossil fuels, the transportation sector is regarded as one of the major emitters of GHGs (Wimbadi et al., 2021). In 2022, the transport sector, with an emission of 8.1 Gt CO_2 equivalents, was responsible for 14% of global net GHG emissions (UNEP, 2023). Population growth together with increasing interest in commercial activities has led to rising trends of passenger car ownership, especially in the big cities (Nguyen-Phuoc et al., 2020). This growing passenger car ownership and usage is further responsible for aggravating negative externalities such as traffic congestion, delays, and vehicular emissions. The toxic exhaust emissions released into the atmosphere substantially deteriorate the urban air quality and are subsequently accountable for health concerns among urban residents (European Environmental Agency [EEA], 2023). Exposure to such harmful pollutants is responsible for increasing the risk of premature death in cities due to diseases such as lung cancer, heart disease, stroke, chronic obstructive pulmonary disease, and respiratory infections (World Health Organization, n.d.). Hence, there is a need to shift towards a sustainable alternative to reduce traffic congestion and vehicular emissions. One such solution is to encourage higher usage of PT among commuters in urban areas (European Environmental Agency [EEA], 2023).

PT is defined as linking a city or different cities with the purpose of providing a convenient travel service and reducing the demand for private car use, which in turn reduces traffic congestion (Institute for Transportation and Development Policy, n.d.). It also has the capacity of carrying multiple travellers, and therefore works most efficiently in large cities with dense population and a higher demand for convenient commuting options (Zheng & Krol, 2023). Alongside biking and walking, PT is also the preferred mode of transportation from an environmental perspective, as it emits less GHGs than single car use. Encouraging a transition from private to public transport can therefore result in a substantial reduction in GHG emissions from the transport sector, which will in turn also contribute to reaching local as well as global climate goals.

To accomplish a higher demand for the use of PT, it is important to identify improvement strategies for the services to ensure that the system is well-designed with inclusivity and convenience to the users (Zheng & Krol, 2023). A well-designed PT system will retain

the current users as well as attract new ones. Furthermore, a well-developed PT system is important in terms of accessibility and affordability (Karjalainen et al., 2023). The affordability is especially important for low-income households who solely rely on PT system for travel purposes. Therefore it is important to have affordable, accessible and well-connected areas through PT. Other sociodemographic characteristics such as gender, age, income, education, etc. could also have an impact.

In 2022 the transport sector was accountable for about 26% of the GHG emissions in the EU-27 (EEA, 2022). Among these emissions, road traffic was accountable for the largest contribution of approximately 60%. In Sweden, the domestic transport sector accounts for approximately one third of the country's total GHG emissions, where 90% comes from road traffic (Trafikverket, 2023). Sweden's larger cities are also facing population growth due to immigration and urbanisation, where the desire to live in or close to cities is rising. One such city is Gothenburg, Sweden's second largest city with a population of almost 600 000 inhabitants located on the southwest coast of Sweden (Statistikmyndigheten, 2022a). As it is a large city, an optimised PT system is a well suited way of transportation (Zheng & Krol, 2023).

PT in Gothenburg is based on a radial system, where trips are made from the outer parts of the city to the centre (Västra Götalandsregionen et al., 2018). The system is based on a tram network and a comprehensive bus network. Trams and trunk bus lines forms the backbone of the network, with local bus lines supplementing and providing more local trips. Alongside, there are a number of train lines originating from the Västra Götalandsregion (VGR) running into Gothenburg city. The fare structure is based on three fare zones covering the entire Västra Götaland region (Västtrafik, n.d.-e). The total number of travellers in Västra Götaland is 376 000 per day (Västtrafik, n.d.-c). Among these travellers, 55% are women and 45% are men (VGR, 2022).

1.2 Problem

Identifying strategies to improve the PT system requires insight in how the consumer perceives the service attributes of PT in their everyday lives. Regular PT users may perceive the service differently compared to the consumers who only uses the PT system occasionally or not at all. It is important to identify which service attributes the users perceive as most valuable and evaluate the result in order to find out what needs improvement. These findings will create opportunities for policy changes with the purpose of increasing the attractiveness and appeal of PT services among the wider population.

An effective way of identifying improvements about the PT service is to base research on the consumer's perspective. Consumer-centric studies are essential to identify the potential drivers and barriers in the transport system. In order to gain this knowledge

from the consumers, in depth research is necessary. This can be achieved by interviewing the consumers about their experiences and opinions. In that way, valuable information regarding improvements of the PT system can be obtained and later be used by the service provider to further improve the existing service. Additionally, consumers with different sociodemographic characteristics such as age, gender, education, income, etc. and different trip-related characteristics such as trip length, trip frequency and trip purpose, may have different perceptions towards various attributes of PT services. Hence, it is important to identify such differences (if any) and include them in policy analysis to attract a wider group of consumers to use PT.

Furthermore, the service provider may also have a different perception about the service which they are providing. One problem is the gap between consumer- and management's perception of the service. This can cause dissatisfaction and decreased trust between the consumer and the supplier, which can reduce the amount of users. The management of the PT service needs to be able to understand the perspective of the consumer.

1.3 Aim and research questions

The main objective of the study is to identify management strategies for improving the PT services in Gothenburg, Sweden. This will be done in terms of analysing consumers' importance and satisfaction towards service attributes, perception of different population sub-groups towards the service attributes, and the service provider's perception towards the current service.

The main objective of the study includes several sub-objectives. Firstly, identifying a comprehensive list of attributes influencing PT usage. Secondly, identifying the perception of consumers' importance and satisfaction with PT service attributes using two-dimensional techniques for data analysis. Further, identifying the variation in perception for service attributes across consumers with different sociodemographic and trip-related characteristics using non-parametric methods. Lastly, to identify the gap between consumers' and service provider's perception for the current PT service by conducting gap analysis. In order to address the aforementioned issues, this study aims to address the following research questions:

1. What are the priority areas of improvement in public transport services based on consumer perception and expectation?
2. Does consumer perception of public transport services vary based on sociodemographic characteristics? If that is the case, in what way?
3. What are the gaps between user perception and service provider's perception of public transport?

1.4 Scope

The scope of the study is limited to investigating consumer perception of PT in Gothenburg city. The scope is further limited to transportation modes, geographical area and time of study. PT in Gothenburg is made up of trams, ferries, local buses, regional buses, express buses and commuter trains. The trams operate from a suburb, through the city and out to another suburb (Västtrafik, n.d.-d). Some lines operate out to Mölndal municipality. Local buses operate all around the municipality, as well as into neighbouring municipalities. Express buses operate from neighbouring cities, through Gothenburg and out to another city. The service provider of the PT system in Gothenburg is the regional agency Västtrafik.

Västtrafik has divided the region into 3 zones, for ticket payment radiating out from Gothenburg, see figure 1. (Västtrafik, n.d.-e). Zone A includes the municipalities of Gothenburg, Mölndal, Partille and Öckerö, see figure 2. Zone B includes the neighbouring municipalities surrounding Zone A. Zone C includes the rest of the region. The price for a single ticket in one zone, that lasts for 90 minutes, is 36 SEK. The price and ticket duration increases when travelling within multiple zones.

This study will investigate the consumer perspective of the buses and trams that operate in zone A, Gothenburg, excluding ferries and commuter trains. As the PT system in Gothenburg is structured in a manner where users utilise both buses and trams, the study considers the two modes of transportation as one. The study has been carried out independently, and not as a part of Västtrafik.

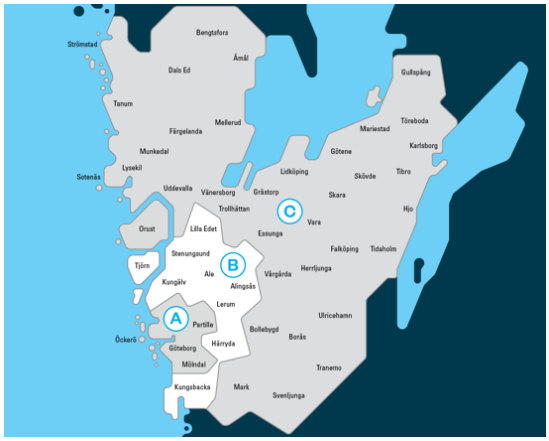

Figure 1: Ticket zones in Västra Götaland Region. (Västtrafik, n.d.-e). Reprinted with permission.

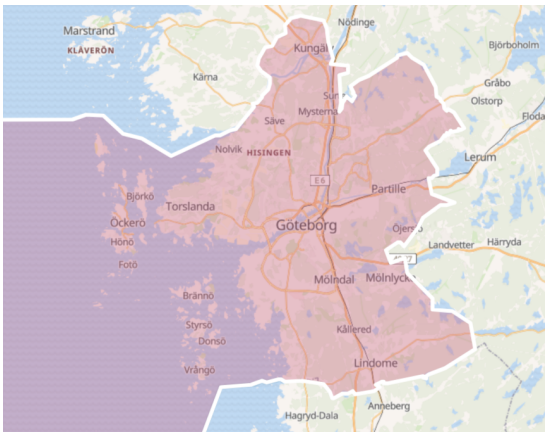

Figure 2: Close-up ticket zone A. (Västtrafik, n.d.-a). Adapted with permission.

2 Literature review

This section presents a literature review of several different studies examining the subject of public transport (PT). The aim of the literature review is to identify service attributes that impact consumers' perception of PT. Additionally, the review of literature includes methodologies used in past studies, and key findings regarding the attributes influencing PT users' overall consumer satisfaction (OCS).

Moslem et al., 2023 performed a study in Mersin City, Turkey with the aim of gaining a deeper understanding of the importance of different attributes associated with PT. This was done in order to encourage a shift from private car usage towards PT. The study was based on interviews to examine the perception of both PT experts and supply operators. The authors categorised the attributes and found that *perspicuity*, *physical comfort* and *directness* was the most important attributes to increase the usage of PT. Additionally, the findings highlighted *speed* and *distance to stop* as important areas for improvement, see table 1 for presented attributes in this study. Dong et al., 2021 conducted a survey-based study in 8 cities in China, consisting of both sociodemographic and travel-related questions. The aim was to investigate how the users' pattern in PT have changed after the COVID-19 pandemic. The results showed that in order to increase the OCS in the aftermath of the pandemic, the service providers should improve areas such as *service frequency*, *information in mobile app*, *punctuality* and *comfort*. Further, Hörcher and Tirachini, 2021 conducted an exhaustive literature review regarding the subject of PT economics and presented key attributes findings. The study showed that attributes such as *fare*, *frequency*, *in-vehicle travel time* and *waiting time* was mentioned in the majority of the analysed literature and therefore has influence on PT.

Van Soest et al., 2019 conducted a literature review with the aim to investigate how the access and egress distances effects the usage of PT. The results showed that although a longer access and egress time is beneficial for the health, the distances needs to be shorter for people to increase their use of PT. Further, the authors conclude that sociodemographics factors such as age, gender and income influence the consumer usage of the PT system. Mouwen, 2015 conducted a survey-based study in Amsterdam, Netherlands, with the aim to analyse consumers perception towards several attributes regarding PT. The respondents rated different PT related attributes as well as their overall satisfaction with PT. The result showed that attributes such as *on-time performance*, *travel speed* and *service frequency* has an major impact of the OCS. The authors recommend service providers to make improvements that targets different sociodemographic groups to maintain these travellers, rather than attract new PT users, see table 2.

Guirao et al., 2016 performed a survey-based study in Madrid, Spain with the aim to identify attributes that has an influence on the service quality of PT. The authors analysed

the result of the questionnaire with stated importance as well as derived importance, and hierarchy method by ranking attributes against each other. The results showed that attributes evaluated using stated importance may have a high rank but does not influence the OCS of the service, which makes the derived importance more useful. When analysing stated importance, the attributes with the highest rank was *cleanliness*, *seating capacity* and *travel time*. Furthermore, when analysing the derived importance the results showed that *route*, *driving security* and *frequency* had the most impact on the OCS. Karlsson and Larsson, 2010 conducted a survey-based study at Chalmers University of Technology in Sweden, Gothenburg with the aim to investigate the perception of *comfort-related* attributes which can affect the OCS. The result showed that factors such as *temperature*, *information regarding the trip*, *seating capacity* and *driving behaviour* had the most influence on experienced comfort with PT. Further, the findings indicated that various factors related to trips and sociodemographics characteristics, including travel time, income and gender, influence the perceived satisfaction with PT.

The review of literature shows that various PT related, sociodemographic, trip-related attributes influence customer's perception and experience of the PT system. The identified attributes influencing consumer perception of PT services are listed in the continuous table 1, 2.

Table 1: Summary of the studied literature

Study	Presented attributes and characteristics
Moslem et al., 2023	**Vehicle attributes**: Physical comfort, safe of travel. **Trip related attributes**: Mental comfort, distance to stops, safety of stops, comfort in stops, need of transfer, fit connections, reliability, journey time, awaiting time, reaching time, time availability, info. before travel, info. during travel, perspicuity. **Sociodemographic characteristics**: -
Dong et al., 2021	**Vehicle attributes**: Secure onboard. **Trip related attributes**: Information before trip, information related to Covid-19, consequences related to Covid-19, probability on mode related to Covid-19, long-term effects of Covid-19, safe at stops, security against Covid-19. **Sociodemographic characteristic**: Gender, age, education, income.
Hörcher and Tirachini, 2021	**Vehicle attributes**: Invehicle travel time, invehicle crowding, vehicle size, seat provision, number and operation of doors. **Trip related attributes**: Access and egress walk time, waiting time, peak time and off peak time, multiperiod services, fare level, frequency, fleet size, representative (aggregate) OD, schedule delay, station crowding, denied boarding, information collection, transfer penalty, demand imbalance factor, line with multiple sections, urban space with uniform demand, monocentric city corridor, network with transfer, stop density, line density, line structure. **Sociodemographic characteristic**: -
Van Soest et al., 2019	**Vehicle attributes**: Vehicle type. **Trip related attributes**: Frequency, density, access and egress time, purpose, time, trip length, transfers, frequency of use. **Sociodemographic characteristic**: Gender, age, available vehicles, driving license, PT card, household size, income, education, employment, ethnicity.

Table 2: Summary of the studied literature (continued)

Study	Presented attributes and characteristic
Mouwen, 2015	**Vehicle attributes**: On board information, cleanliness, ease of boarding and alighting, seating capacity, on board noise, safety on board. **Trip related attributes**: On-time performance, travel speed, frequency, fare, personnel behaviour, drivers behaviour, ticket system, information at stops, safety at stops. **Sociodemographic characteristics**: Gender, age, number of weekly PT trips, car availability, negative safety experience.
Guirao et al., 2016	**Vehicle attributes**: Cleanliness, comfort. **Trip related attributes**: Punctuality, frequency, info-incidents, info-service, route, connections, access, journey time, information and communication technologies. **Sociodemographic characteristics**: Age, gender, trip purpose, frequency of trip, ticket type, occupation.
Karlsson and Larsson, 2010	**Vehicle attributes**: Temperature, availability of seat, comfortable seat, cleanliness, smell, noise, illumination, crowd, storage possibilities, smooth driving. **Trip related attributes**: - **Sociodemographic characteristics**: Gender, age, travel time, travel frequency, car availability.

3 Theoretical background

This section presents the theoretical background for the selected statistical analysis methods used to carry out the study.

3.1 Importance Performance Analysis

Importance Performance Analysis (IPA) is a statistical analysis technique, introduced by Martilla and James in 1977 (Martilla & James, 1977). The aim of the technique is to identify improvement areas of service by evaluating importance and customer satisfaction of different attributes. IPA is commonly used among different service providers for service evaluation and quality improvement. Data is typically collected through customer satisfaction surveys where importance and performance (satisfaction) is measured through some kind of self-stated measure, e.g. through a rating scale. The data is then compiled into a two-dimensional matrix with attribute importance on the x-axis, and attribute performance on the y-axis (Matzler et al., 2003). The matrix is divided into four quadrants. Determining the axes placement can be done in different ways, the most common being by taking the total means of importance, and the total means of performance. See figure 3. The mean values of importance and performance for each attribute are then to be scattered as points in the matrix, in order to identify the priority areas of improvement.

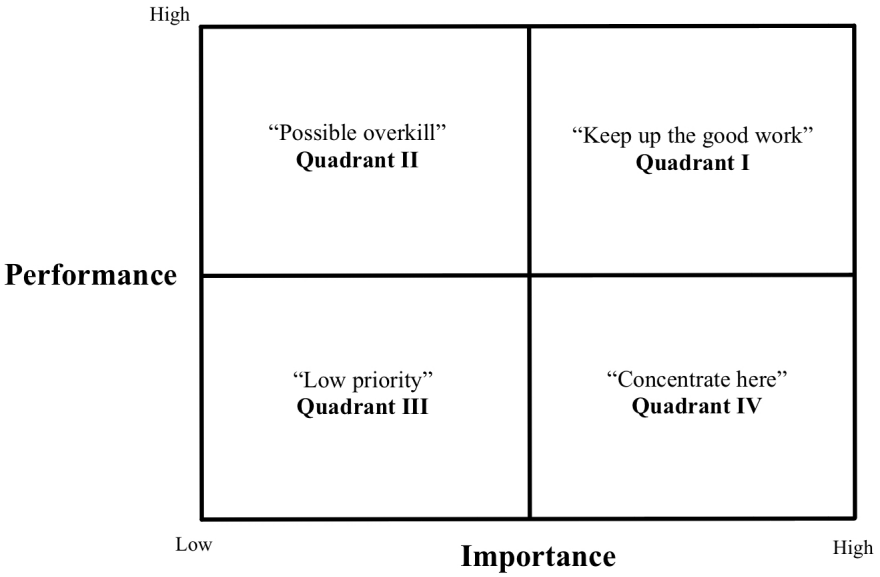

Figure 3: IPA matrix

Attributes in Quadrant I are of high importance and high performance, with the management scheme "Keep up the good work" (Matzler et al., 2003). These attributes are

major strengths and their standards should be maintained to keep the current service quality. Attributes in Quadrant II are minor strengths, with low importance and high performance. Resources dedicated to these attributes could be of better use distributed elsewhere, since these attribute are a "Possible overkill". Attributes in Quadrant III are of low importance and low performance and therefore of "Low priority". These attributes are minor weaknesses and do not require additional effort. Lastly, attributes in Quadrant IV are major weaknesses, with high importance and low performance. This indicates that they require effort for service quality improvement, and are therefore in the management scheme "Concentrate here".

3.2 Revised IPA

IPA is based on two assumptions; (1) that attribute performance and attribute importance are independent variables and (2) that the relationship between attribute performance and overall customer satisfaction (OCS) is linear and symmetrical (Matzler et al., 2004). W. Deng, 2007 presents multiple studies showing that these assumptions are not representative in the real world, as attribute performance and attribute importance are dependent variables and that their relationship therefore is causal, as well as the relationship between attribute performance and OCS being asymmetrical. This means that changes in attribute performance will in fact influence the relative importance of that attribute, making the customer's self-stated importance not practicable (W. Deng, 2007). This has resulted in revised IPA, which is a modification of the traditional IPA where these limitations are avoided.

Three factor theory of customer satisfaction suggests that service attributes can be divided into three categories; *basic factors*, *performance factors* and *excitement factors* (W. J. Deng et al., 2008). Basic factors, or dissatisfiers, are the minimum requirements and attributes expected to be fulfilled. This means that they generate customer dissatisfaction when not exceeded, but no increased customer satisfaction when fulfilled. The relationship between basic factors and OCS is non-linear and asymmetrical. Performance factors produce satisfaction when delivered and dissatisfaction when not delivered. Therefore, the relationship between performance attributes and OCS is linear and symmetrical. Excitement factors, or satisfiers, are attributes that increase customer satisfaction when exceeded but do not cause dissatisfaction when not exceeded. The relationship between excitement factors and OCS, as for the basic attributes, is non-linear and asymmetrical.

Revised IPA uses implicitly derived importance instead of customer self-stated importance, which is based on the attribute's correlation between performance and OCS and the characteristic attribute categories from three-factor theory are incorporated (W. Deng, 2007; W. J. Deng et al., 2008). This removes the potential problems of linear and symmetrical relationships between the variables, which makes it superior to stated importance.

Since there is also potential for multicollinearity existing within the independent variables, partial correlation analysis is a suitable method to determine the derived importance for each attribute. This is used together with natural logarithmic transformation of the independent variables, which can give a better representation of diminishing returns and better sensitivity in the data.

By first converting all the attributes' performance to natural logarithmic form, partial correlation analysis is used to determine the partial correlation coefficient for each performance attribute with OCS (W. Deng, 2007; W. J. Deng et al., 2008). Partial correlation is then executed for each value, with one performance value and OCS as dependent variables, controlling for the rest of the natural logarithmic performance values as independent variables. The partial correlation coefficient is the implicitly derived importance for respective attribute.

To obtain the revised IPA matrix, the attribute's derived importance is plotted as the x-coordinate, the attribute's performance is plotted as the y-coordinate and the respective total mean values can be used as the axes dividing the quadrants (W. Deng, 2007). This generates the management scheme explained in sub-section 3.1. The revised IPA matrix for the factor structure is obtained by plotting the attributes, with stated importance as the x-coordinate and the derived importance as the y-coordinate and the respective mean values as the axes (Matzler et al., 2003). See figure 4.

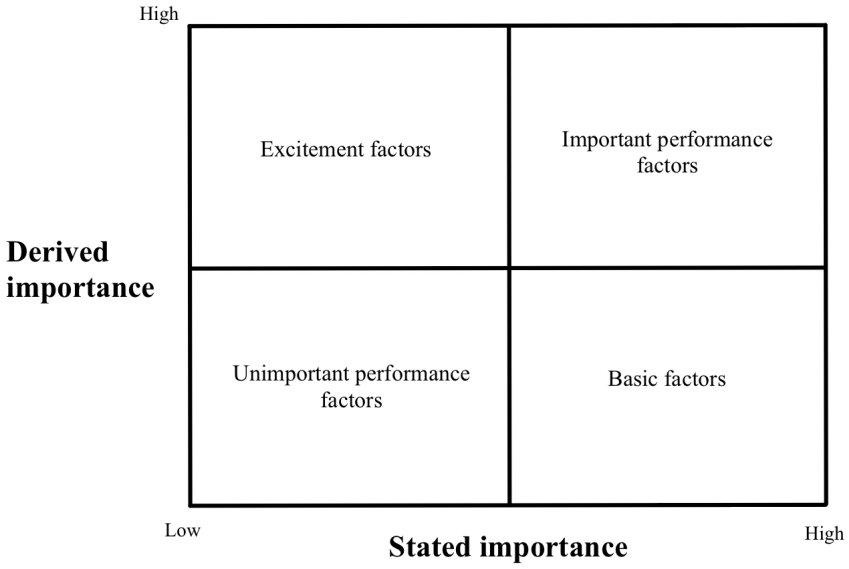

Figure 4: Revised IPA providing the three-factor structure

3.3 RIDIT Analysis

In scientific studies it happens that researchers encounter response variables that lie between dichotomous classifications and refined measurement systems (Bross, 1958). These variables can include subjective scales or numerical values influenced by various factors such as experimental material quality or protocol details. Traditional statistical methods like chi-square tests or t-tests may not fully capture the nuances of such "borderland" variables. In such cases, RIDIT analysis, founded by Bross, 1958, provides a valuable bridge between these two traditional families of statistical methods. Ridits are calculated based on the observed distribution of the data. This approach is beneficial when dealing with real-world data, as it allows for a more flexible and data-driven transformation.

RIDIT analysis, short for Relative to an Identified Distribution Integral Transformation, is a statistical method designed for assessing the importance of service attributes using ordinal data (Jiten Shah et al., 2021). This technique involves transforming the ordered response variable into ridit scores through a probability integral transformation using an empirical distribution function. Ridit scores represent the relative position of each category within the distribution of the responses, ranging from 0 to 1. Lower ridit values indicate lower satisfaction with the transit service attribute being assessed meaning a higher importance. RIDIT analysis, involves several key steps that result in a ranking of different variables (Bross, 1958). Initially, the ordinal categories are ranked according to their inherent order or hierarchy. Following this, RIDIT scores are computed for each category, meaning the level of satisfaction from the survey, representing the proportion of observations falling below it. In the context of ordinal data, these scores are calculated using cumulative probabilities or frequencies to accurately reflect the ordinal nature of the data. These RIDIT scores then enable a comparison across different groups, enabling the evaluation of distributional differences in the data. This methodology offers a robust approach to analysing ordinal data, accommodating the natural order of categories while providing a non-parametric means of comparison that does not necessitate strict assumptions about the data's underlying distribution.

3.4 Spearman's Rank-Order Correlation

Spearman's correlation coefficient quantifies the degree of a monotonic association between paired data points (Aryan Gupta, 2023). Spearman's correlation coefficient is applicable when assessing the strength and direction of a relationship between variables that may not have a linear association, making it suitable for when the data is being ranked. It involves comparing ranks between different sub-groups, yielding a correlation value ranging from 0 to ± 1. A correlation value closer to ± 1 suggests a stronger correlation, indicating similar rankings between sub-groups. Conversely, a value closer to 0 indicates a lack of correlation, signifying divergent attribute rankings between sub-groups.

4 Methodology

This section explains the methods used to carry out the study. This includes identification of attributes, design of survey instrument, data collection, data organisation, data investigation and analysis.

4.1 Design of survey instrument

This sub-section delves into the process of identifying attributes influencing user perception and the design of the survey instrument.

4.1.1 Identification of comprehensive set of attributes influencing user perception for public transport services

The first part of the project consisted of an exhaustive review of literature with the purpose to identify key attributes that impacts user perception of PT services. This involved an examination of scholarly articles and research papers from past studies conducted in both developed and developing countries, see section 2. Based on the literature review, a list of 20 attributes has been considered in the present study for analysing user perception for PT services. The attributes and their definitions are presented in table 3.

From the review of literature it is evident that multiple sets of attributes influence consumer importance and satisfaction for PT systems in different study contexts. However, attributes such as *frequency*, *punctuality*, *comfort*, *cleanliness*, *information related to the trip*, *travel time*, *safety on board and at stops* and *security* are identified common sets of factors influencing user perception for PT in different studies, and hence are also considered as relevant in the present study context. To have detailed understanding on trip related information this study include *information in mobile app*, *ticketing system*, *onboard information* and *information at stop* as four separate attributes. The attribute *stop illumination* has also been mentioned in some of the studies in reference to *safety at stops*. This has been added as a separate attribute since the PT system in Gothenburg extends into areas with less dense population and therefore less illuminated. Further, attributes related to the trip and transfers, such as *number of transfers*, *transfer time*, *accessibility and time to stop*, *ease of boarding and alighting*, *crowding on board*, *seating capacity* and *span of service* have been included in past studies and is identified as relevant for understanding user perception of the PT system in Gothenburg. Although *fare* has been included as an attribute in only a few studies, it is identified as an important attribute to analyse the user acceptance of PT services in Gothenburg.

Table 3: Attribute definitions and number in study

Number	Attribute	Definition
1	Punctuality	Consistent and timely adherence to scheduled departure and arrival times.
2	Service frequency	Time interval of vehicle availability along a route.
3	Span of service	Time duration for which the service is operational during a day along a route.
4	Fare	Amount of money required to be paid for using the service.
5	Comfort	Degree of experienced comfort while travelling. For example, comfort in terms of occupying a seat, standing, on-board noise and vehicle temperature.
6	Information in mobile app	Digital platform providing real-time and relevant data, updates, or details catering to trip maker's needs, or inquiries through mobile application interface.
7	Ticketing system	Type of ticketing system i.e., on-board, off-board and online ticketing.
8	Travel time	Total time spent inside a vehicle during a journey.
9	Cleanliness	Maintenance of dirt-free and orderly environment inside the vehicle.
10	Crowding on board	Degree of crowding. For example seat availability, or experience when standing in crowded conditions.
11	On-board information	Real-time updates provided inside bus/tram during the journey, including route information, announcements, etc.
12	Seating Capacity	Maximum number of passengers the vehicle can accommodate with designated seating arrangements.
13	Ease of boarding and alighting	Convenience of getting on and off the vehicle.
14	Transfer time	Total time taken for transfer from one bus/tram to another to reach the destination, which includes walking from one bus/tram stop to another and waiting time.
15	Number of transfers	Total number of changes from one bus/tram to another before reaching the destination.
16	Accessibility and time to stop	Time taken to reach bus/tram stop from home and from bus/tram stop to the destination.
17	Information at stop	Information available to the trip makers at the bus/tram stop, encompassing routes, schedule, delays, etc.
18	Stop illumination	Provision of lighting at designated stops to enhance visibility during low-light conditions.
19	Safety on board	Precautions to reduce the risk of exposure to injury or danger during the event of an accident.
20	Security	Measures ensuring protection against any form of danger or theft, within the vehicle, and at stops.

4.1.2 Design of questionnaire

After identifying the set of attributes for addressing the research questions, the questionnaire was designed. It was divided into four parts. The first part of the questionnaire consisted questions regarding the user's regular way of travelling, such as travel mode and travel frequency. This was valuable in order to gain information about travel profiles of the respondents and PT usage. The second part contained both importance and satisfaction rating-scale questions for each of the 20 chosen attributes. It also consisted of one question about the traveller's overall satisfaction with the PT system. This was a key question in order for the statistical analysis to be done. The third part consisted of questions about the traveller's most common trip, which contributed with more information about the traveller's habits. The last part contained questions about the traveller's sociodemographic information. The characteristics chosen were gender, age, education, income, occupation, travel frequency and car accessibility, from the literature study.

Before conducting the main survey, a pilot pre-test was conducted on 10 randomly selected respondents from zone A in Gothenburg. The purpose of the pilot survey was to ensure the clarity of the questions. After incorporating necessary refinements and corrections based on the suggestions of the respondents, the final version of the questionnaire was available to carry out the main survey. See Appendix A and B for the English and Swedish version of the questionnaire.

4.2 Data collection and organisation of data

This sub-section explains the methodology of data collection and organisation, which was conducted on PT users as well as the PT service provider in Gotheburg, Västtrafik.

4.2.1 Public transport users

The data collection on PT users consisted of an online questionnaire, which was limited to travellers within zone A. Data was collected through the questionnaire being sent out in Gothenburg-related Facebook groups and being shared on various social media platforms. People were also randomly approached on trams, buses, at stops and other everyday places around the city. When organising the data, each sociodemographic characteristic was divided into two sub-groups. For gender, the counterparts are male and female, since others were a significant small minority. For age, it was divided between people under and over the age of 35 years, since this is the mean age of the population in Gothenburg (Statistik och Analys stadsledningskontoret Göteborgs Stad, n.d.). The travel frequency was divided so that people travelling 4 times or less are infrequent PT users, and people using it more are frequent users. For income the counterparts are people with income lower and higher than 35 000 SEK per month. This number represents the approximate median income in Sweden 2022 (Statistikmyndigheten, 2022b). The car accessibility was

divided between people with and without access to a car.

4.2.2 Service providers

When beginning to investigate the service provider's perception, the answers from the service users questionnaire had already been obtained, providing an initial understanding of customers' perception of importance and satisfaction of the PT service. In order to obtain the service provider's perspective on the selected attributes, two extensive interviews were held with employees at Västtrafik, to gain qualitative data. A questionnaire was also sent out to the employees, which yielded quantitative data. See Appendix C for the questionnaire. The employees answered questions about Västtrafik's perception of the selected attributes in terms of importance and satisfaction of their provided service.

The first interview was held with Sharon Plotzki, development manager and Lovisa Borgström, community developer at Västtrafik. They were asked about Västtrafik's perception of each of the selected attributes and encouraged to further develop their thoughts. The interview was based on the same set of questions as the service provider questionnaire, seen in Appendix C. The second interview was with Lisa Nordberg, head of a customer strategy department, with the purpose of delving into the ticket pricing of their service, since *fare* was a clear area of dissatisfaction obtained from the service users questionnaire. The interview questions that were discussed during the interview can be seen in the Appendix D. The data collected from the interviews and questionnaire was later used to identify the gap in perceptions between the provider and the users.

4.3 Data analysis and result

The data analysis was made using statistical analysis methods; revised IPA and RIDIT scoring and Spearman rank, presented in the Theoretical background, section 3. This provided meaningful insights and results for the problem at hand.

4.3.1 Revised IPA

Revised IPA is a commonly used method to analyse consumer satisfaction and importance, and was conducted in order to answer research question 1: *What are the priority areas of improvement in public transport services based on consumer perception and expectation?* The revised IPA was conducted using the digital statistical analysis tool SPSS (IBM, n.d.). As a first step, the performance data for the PT users was converted to natural logarithmic form. Then considering OCS data as dependent variable and natural logarithmic form of individual attribute performance data as independent variables. Partial correlation analysis was performed to determine derived importance for each attribute. The values of derived importance, the mean stated performance and mean importance were normalised for each attribute to achieve a standard data format

for comparison. Python programming language was used to plot the two dimensional grid of IPA matrices. The mean of the normalised values of the attributes were used for the placement of the axes of the matrices. A revised IPA matrix providing the management scheme, with derived importance on the x-axis and performance on the y-axis as well as a matrix providing the factor structure with stated importance on the x-axis and derived importance on the y-axis, were plotted. See Appendix E for the Python-code.

Revised IPA was conducted for the overall sample, as well as for sub-groups comprising individuals with and without access to a car. The reason to separately analyse car accessibility with revised IPA was to gain insights on whether there is any difference in perception for PT service attributes across car-users and non-car users. Attracting car-users to choose PT services is one of the primary goals to reduce traffic congestion and vehicular emissions. This analysis enables conclusions to be drawn about necessary policies to encourage a shift from passenger car ownership to PT.

4.3.2 RIDIT scoring and Spearman rank

RIDIT analysis was conducted to enable a ranking of the attributes for all the sociodemographic groups. It is one of the few ranking systems that does not assume an underlying distribution of the data and is relevant for ranking the ordinal dataset used in this study. This multi-criteria decision making technique was used to address the second research question: *Does consumer perception of public transport services vary based on sociodemographic characteristics? If that is the case, in what way?*

The following four sociodemographic and trip-related characteristics; gender, age, frequency of PT usage and income, were analysed using this method. Ridit scores for each attribute were derived for each sub-group. Subsequently, these ridit scores were used to rank attributes based on both importance and satisfaction data. The ridit scores were calculated for each group using python, full code can be found in the Appendix F. A Spearman rank correlation was conducted using SPSS to investigate the extent of correlation between sub-groups for each sociodemographic characteristic. This process was repeated for all four groups, considering both importance and satisfaction data.

4.3.3 Analysis of the gap between consumer and provider satisfaction

An analysis of the gap in perception between PT users and the service provider was conducted in order to answer research question 3: *What are the gaps between user perception and service provider's perception of public transport?* The answers from the service providers' questionnaire were analysed by calculating the mean of the stated satisfaction of each attribute. The same was done for the consumers'. Then the mean for the consumers was subtracted from the service providers' in order to receive the gap between perceptions.

5 Results

In this section, the results of the revised IPA, RIDIT analysis, Spearman rank and gap analysis are presented, in order to answer the research questions.

5.1 Preliminary investigation and description of the statistical data

A total number of 674 answers were collected anonymously through the consumer survey. After data cleaning, the dataset for the analysis consisted of 638 answers. This is a representative sample dataset to perform statistical analysis (Taherdoost, 2016). These answers were collected in zone A, Gothenburg. The sociodemographic distribution of the collected data was then compared with statistical data about the general sociodemographic information of Gothenburg. It was found that females were overrepresented in the survey, as well as students and people under the age of 35. Simultaneously, people with access to a car were underrepresented in comparison to the population of Gothenburg. This is shown in table 4. From the service providers' questionnaire, five answers were collected.

Table 4: Data comparisons

Sociodemographic information	**Respondents in this study**	**Gothenburg**
Gender	Female: 64,6% Male: 32,9% Others: 2,5%	Female: 49,6 % ** Male: 50,4 % ** Others: -
Age	$\leq$ 35 years: 72,1 % $>$ 35 years: 27,9 %	$\leq$ 35 years: 48,6 % ** >35 years: 51,4 % **
Income	$\leq$ 35 000 SEK: 72,1 % >35 000 SEK: 27,9 %	$\leq$ 35 000 SEK: $\sim$ 50%*** >35 000 SEK: $\sim$ 50%***
Access to car	Access: 41,4 % No access: 58,6 %	Access: 72 % * No access: 28 % *
Frequency	Frequent users: 51,9 % Infrequent users: 48,1 %	Frequent users: - Infrequent users: -
Students	Studying: 48 %	Studying: 10 % ****
PT as main travelling mode	Total: 66 %	Total: 45 % *

* Västra Götalandsregionen, 2023

** Statistik och Analys stadsledningskontoret Göteborgs Stad, n.d.

*** Statistikmyndigheten, 2022b

****Sveriges Förenade Studentkårer [SFS], 2023 The number of students from the SFS data were divided with the population of Gothenburg.

5.2 Priority areas of improvement in PT based on consumer perception

The results in this sub-section addresses research question 1, using revised IPA in order to obtain areas of improvement for the overall sample and sub-samples of car acces and no car access.

5.2.1 Management scheme

Figure 5 shows the revised IPA matrix providing the management scheme for the overall sample. The attributes in quadrant IV, the ones of highest importance and lowest performance, are *punctuality* (1), *fare* (4), *comfort* (5) and *number of transfers* (15). These have the management scheme "Concentrate here" and are the PT system's major weaknesses based on the perception of the overall sample. See table 5 for the management scheme for all attributes.

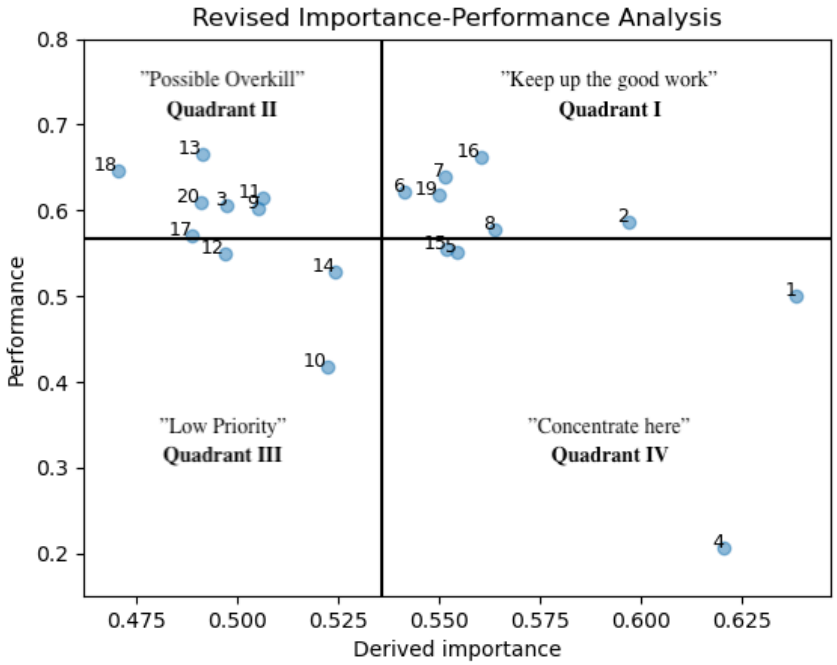

Figure 5: Revised IPA providing the management scheme for the overall sample

Table 5: Management scheme for overall sample

"Keep up the good work"	**"Possible overkill"**	**"Low priority"**	**"Concentrate here"**
2: Service frequency	3: Span of service	10: Crowding on board	1: Punctuality
6: Information in mobile app	9: Cleanliness	12: Seating capacity	4: Fare
7: Ticketing system	11: On-board information	14: Transfer time	5: Comfort
8: Travel time	13: Ease of boarding and alighting		15: Number of transfers
16: Accessibility and time to stop	17: Information at stop		
19: Safety on board	18: Stop illumination		
	20: Security		

Figure 6 shows the revised IPA matrices providing the management schemes for the sub-samples of car access and no car access. The matrices show that *punctuality* (1) and *fare* (4) are the common major weaknesses according to both people with and without access to a car. People with access to a car also have *service frequency* (2), *travel time* (8) and *numbers of transfers* (15) in the "Concentrate here" category, while people without acess to a car see *comfort* (5) as a priority. See table 6 for the management scheme of the sub-samples car access and no car access.

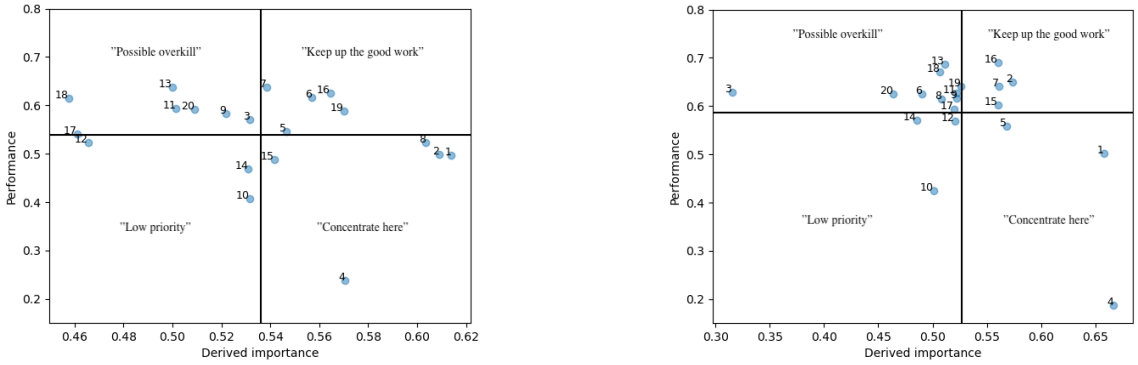

Figure 6: Comparison of management schemes between car access (left) and no car access (right).

Table 6: Comparison of management schemes between car access and no car access

Management type	**Car access**	**No car access**
"Keep up the good work"	Comfort (5), Information in mobile app (6), Ticketing system (7), Accessibility and time to stop (16), Safety on board (19)	Service frequency (2), Ticketing system (7), Number of transfers (15), Accessibility and time to stop (16)
"Possible overkill"	Span of service (3), Cleanliness (9), On-board information (11), Ease of boarding and alighting (13), Information at stop (17), Stop illumination (18), Security (20)	Span of service (3), Information in mobile app (6), Travel time (8), Cleanliness (9) On-board information (11), Ease of boarding and alighting (13), Information at stop (17), Stop illumination (18), Safety on board (19), Security (20)
"Low priority"	Crowding on board (10), Seating capacity (12), Transfer time (14)	Crowding on board (10), Seating capacity (12), Transfer time (14)
"Concentrate here"	Punctuality (1), Service frequency (2), Fare (4), Travel time (8), Number of transfers (15)	Punctuality (1), Fare (4), Comfort (5)

5.2.2 Factor structure

Figure 7 shows the factor structure for the overall sample. The revised IPA matrix for the factor structure shows that the only basic factor is *security* (20), meaning that security generates no satisfaction when fulfilled but great dissatisfaction when not fulfilled. The important performance factors are *punctuality* (1), *service frequency* (2), *fare* (4), *information in mobile app* (6), *travel time* (8), *number of transfers* (15), *accessibility and time to stop* (16) and *safety on board* (19). These attributes generate satisfaction when delivered and dissatisfaction when not delivered, and are of more important character than the unimportant performance factors. The unimportant performance factors are *span of service* (3), *cleanliness* (9), *crowding on board* (10), *on-board information* (11), *seating capacity* (12), *ease of boarding and alighting* (13), *transfer time* (14), *information at stop* (17) and *stop illumination* (18). Excitement factors imply the attributes generating satisfaction when provided but no extra dissatisfaction when not provided, and consist of *comfort* (5) and *ticketing system* (7).

See table 7 for a clear summary over the attribute's factor structure for the overall sample.

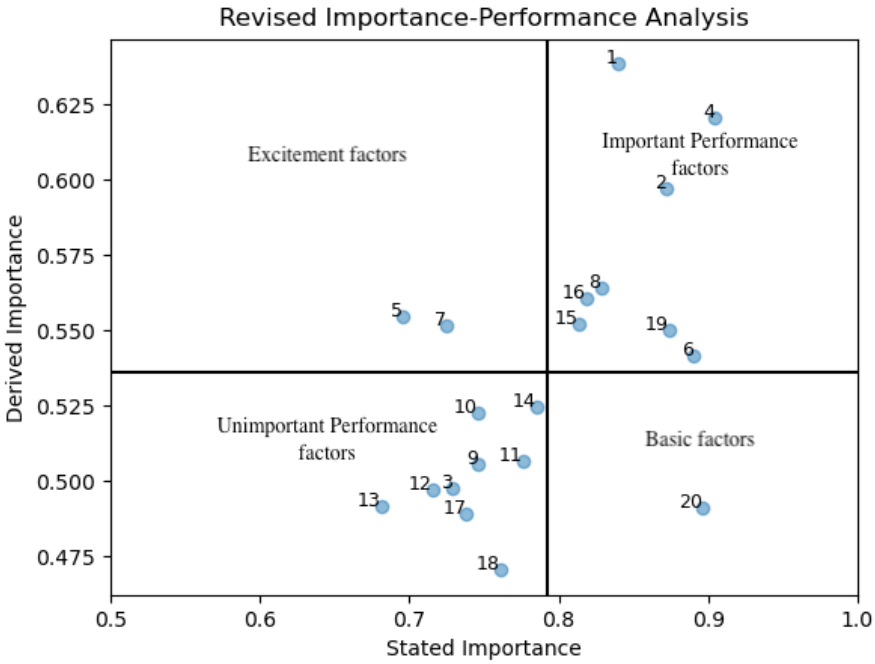

Figure 7: Revised IPA providing the factor structure

Table 7: Factor structure for the overall sample

Important performance factors	**Unimportant performance factors**	**Basic factors**	**Excitement factors**
1: Punctuality	3: Span of service	20: Security	5: Comfort
2: Service frequency	9: Cleanliness		7: Ticketing system
4: Fare	10: Crowding on board		
6: Information in mobile app	11: On-board information		
8: Travel time	12: Seating capacity		
15: Number of transfers	13: Ease of boarding and alighting		
16: Accessibility and time to stop	14: Transfer time		
19: Safety on board	17: Information at stop		
	18: Stop illumination		

Figure 8 shows a comparison of the factor structures between the sub-samples of car access and no car access. Most of the attributes have a similar factor structure, however there are some differences. As to be seen in table 8, the excitement factors are the same for both car access and no car access, consisting of *comfort* (5) and *ticketing system* (7). The basic factors are similar for car access and no car access, consisting of *transfer time* (14) and *security* (20). For people without access to a car, *information in mobile app* (6) is also a basic factor. For people with access to a car, this attribute is instead an important performance factor along with *punctuality* (1), *service frequency* (2), *fare* (4),

crowding on board (10), *number of transfers* (15), *accessibility and time to stop* (16) and *safety on board* (19). Non car access have *punctuality* (1), *service frequency* (2), *fare* (4), *number of transfers* (15), *accessibility and time to stop* (16) and *safety on board* (19) as important performance factors. Lastly, the unimportant performance factors, that are similar for people with and without access to a car, are *span of service* (3), *cleanliness* (9), *on-board information* (11), *seating capacity* (12), *ease of boarding and alighting* (13), *information at stop* (17) and *stop illumination* (18). For people with no car access, *crowding on board* (10) and *transfer time* (14) are unimportant performance factors as well. This is presented in table 8.

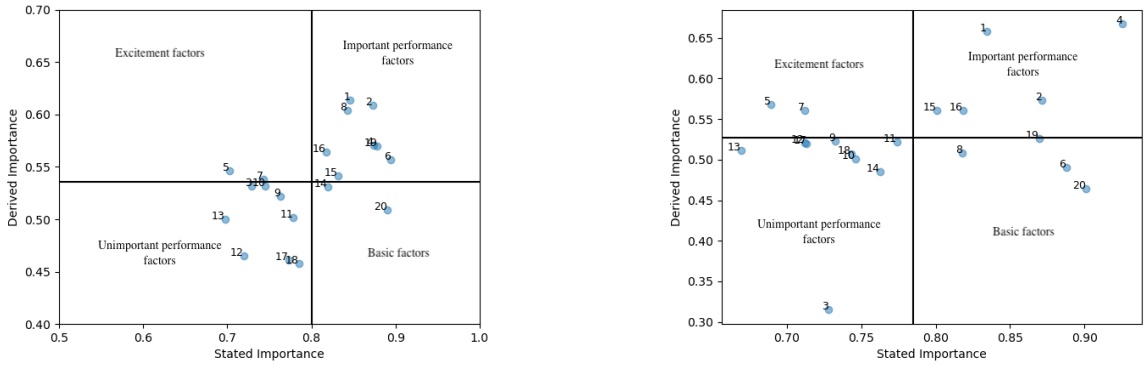

Figure 8: Comparison of factor structures between car access (left) and no car access (right).

Table 8: Comparison of factor structure between people with access to a car and without access to a car

Factor structure	**Car access**	**No car access**
Important performance factors	Punctuality (1), Service frequency (2), Fare (4), Information in mobile app (6), Travel time (8) Crowing on board (10), Number of transfers (15), Accessibility and time to stop (16) Safety on board (19)	Punctuality (1), Service frequency (2), Fare (4), Number of transfer (15), Accessibility and time to stop (16), Safety on board (19)
Unimportant performance factors	Span of service (3), Cleanliness (9), On-board information (11), Seating capacity (12), Ease of boarding and alighting (13), Information at stop (17), Stop illumination (18)	Span of service (3), Cleanliness (9), Crowding on board (10), On-board information (11), Seating capacity (12), Ease of board and alighting (13), Transfer time (14), Information at stop (17), Stop illumination (18)
Basic factors	Transfer time (14), Security (20)	Information in mobile app (6), Travel time (8), Security (20)
Excitement factors	Comfort (5), Ticketing system (7)	Comfort (5), Ticketing system (7)

5.2.3 Comparison of management scheme and factor structure to obtain priority attributes

Improvement strategies for PT services were identified by comparing the factor structure and management scheme. The order of priority for improvement are as follows; (1) basic factors falling under "Concentrate here", (2) performance factors falling under "Concentrate here" and (3) excitement factors falling under "Concentrate here" (Cheranchery & Maitra, 2017).

As seen in table 9, there are no basic factors falling under "Concentrate here" for all the investigated groups. Hence, for the overall sample, the performance factors; *punctuality*, *fare* and *number of transfers* are the main areas of improvement in PT, followed by *comfort*, which is an excitement factor. All these factors fall under "Concentrate here". *Punctuality, service frequency, fare, travel time* and *number of transfers* are the priority areas of improvement based on the perception of people with access to a car. For people without access to a car, *punctuality* and *fare* are the the most important attributes to

improve, followed by *comfort*.

Table 9: Comparison of factor structure and management scheme

	Overall sample	**Car acess**	**No car access**
Basic factors in "Concentrate here"	-	-	-
Performance factors in "Concentrate here"	Punctuality, Fare, Number of transfers	Punctuality, Service frequency, Fare, Travel time, Number of transfers	Punctuality, Fare
Excitement factors in "Concentrate here"	Comfort	-	Comfort

5.3 Consumer perception of PT based on sociodemographic characteristics

The results of the RIDIT analysis shows the rank of each attribute for all the sub-groups, to answer research question 2. For rank of the importance see table 10 and for the satisfaction see table 11. For importance, the result of the Spearman rank correlation showed that the rank for each attribute did not vary much in the sociodemographic groups, since all the values are near 1, see table 10. However, for the satisfaction the Spearman rank correlation showed that all the sociodemographics groups except gender had a value close to 0, which means that the sub-groups rank the attributes differently, see table 11. For instance, the group with the Spearman value for satisfaction closest to 0 was income, although the value for importance was closer to 1. This means that both income above the median and income below the median value the importance of each attributes similar but the satisfaction for each attribute are not alike.

Table 10: RIDIT Ranking of stated importance
M= male, F= female, Y= Age $\leq$ 35, O= Age $>$ 35, Fr= Frequent PT user,
IFr= Infrequent PT user, LI= Income $\leq$ 35 000 SEK, HI= Income $>$ 35 000 SEK

Attribute	**M**	**F**	**Y**	**O**	**Fr**	**IFr**	**LI**	**HI**
Punctuality	7	6	6	7	6	7	6	7
Service frequency	4	5	5	4	4	5	5	1
Span of service	12	18	13	20	16	16	14	19
Fare	1	1	1	5	1	1	1	8
Comfort	13	17	16	17	18	14	16	17
Information in mobile app	2	3	3	1	2	3	3	2
Ticketing system	18	16	18	14	19	15	19	16
Travel time	6	8	7	6	7	6	8	5
Cleanliness	11	4	10	16	11	11	10	11
Crowding on board	14	14	15	15	13	17	15	14
On-board information	16	10	12	12	10	12	12	12
Seating capacity	15	19	17	18	17	19	18	18
Ease of boarding and alighting	20	20	20	19	20	20	20	20
Transfer time	10	12	11	13	12	10	11	9
Number of transfers	9	9	9	8	9	8	9	6
Accessibility	8	7	8	10	8	9	7	10
Information at stop	17	15	19	9	15	18	17	15
Stop Illumination	19	11	3	11	14	13	13	13
Safety	5	4	4	3	5	4	4	3
Security	3	2	2	2	3	2	2	4
Spearman Rank	0,836		0,791		0,941		0,892	

Table 11: RIDIT Ranking of stated satisfaction
M= male, F= female, Y= Age $\leq$ 35, O = Age > 35, Fr= Frequent PT user,
IFr= Infrequent PT user, LI= Income $\leq$ 35 000 SEK, HI= Income > 35 000 SEK

Attribute	**M**	**F**	**Y**	**O**	**Fr**	**IFr**	**LI**	**HI**
Punctuality	16	11	16	11	16	8	14	11
Service frequency	18	15	9	20	12	19	6	20
Span of service	10	18	18	9	11	17	12	15
Fare	2	1	1	1	1	1	1	8
Comfort	1	2	2	3	2	2	3	3
Information in mobile app	14	20	19	15	20	16	19	16
Ticketing system	20	19	20	17	19	20	20	13
Travel time	15	12	6	19	3	18	4	19
Cleanliness	7	4	10	2	7	5	8	2
Crowding on board	19	10	14	18	15	14	16	14
On-board information	13	16	15	12	17	9	17	9
Seating capacity	8	6	7	7	13	4	9	7
Ease of boarding	12	17	17	8	14	13	15	12
Transfer time	9	13	4	16	8	11	2	18
Number of transfers	17	8	12	10	10	15	7	17
Accessibility	4	9	5	13	6	10	10	10
Info at stop	11	14	11	14	18	6	18	4
Stop Illumination	3	3	3	4	5	3	5	1
Safety	6	5	8	6	4	12	11	6
Security	5	7	13	5	9	7	13	5
Spearman Rank	0,692		0,337		0,392		0,008	

5.4 Service provider's perception of PT

The following sub-section outlines the disparities in satisfaction between service consumers and the provider, and further presents insights into the service providers' perception of PT obtained from interviews. This answers research question 3.

5.4.1 Differences in satisfaction between PT users and service provider

The differences between the customer and service providers satisfaction are shown by subtracting the service providers satisfaction mean from the customer satisfaction mean for each attribute. When the differences between the service providers and the customers are a positive value it means that the service providers are more satisfied than the customers. On the opposite, when the value is a negative number it indicates that the customers are more satisfied than the service providers. For only one attribute the service providers

and the customers are equally satisfied, which is the attribute *punctuality*. The results are shown in table 12.

Table 12: Comparison between service provider satisfaction and user satisfaction

Attribute	**Satisfaction Service Provider**	**Satisfaction Users**	**Satisfaction Gap**
Punctuality	3,0	3,0	0
Service Frequency	3,2	3,3	-0,1
Span of service	4	3,4	0,6
Fare	3,2	1,8	1,4
Comfort	4	3,2	0,8
Information in mobile app	3,8	3,5	0,3
Ticketing system	3,4	3,6	-0,2
Travel time	3	3,3	-0,3
Cleanliness	4,2	3,4	0,8
Crowding on board	3,8	2,7	1,1
On-board information	3,2	3,5	-0,3
Seating capacity	4	3,2	0,8
Ease of boarding	3,4	3,7	-0,3
Transfer time	3	3,1	-0,1
Number of transfers	3	3,2	-0,2
Accessibility	3	3,7	-0,7
Information at stop	3,2	3,3	-0,1
Stop illumination	2,8	3,6	-0,8
Safety on board	3,6	3,5	0,1
Security	3	3,4	-0,4

The most tangible differences between customers' and provider's perception is the *fare*, where the provider is over 75% more satisfied than the costumers. The second largest gap is *crowding on board*, where the provider is over 40% more satisfied. Other attributes where the provider is significantly more satisfied than the customers are *comfort*, *cleanliness* and *seating capacity*. However, there also exist attributes that the provider is less satisfied with in comparison to the travellers. The most tangible ones being *stop illumination* and *accessibility*. There are several attributes where the gap in satisfaction between the provider and customers are relatively low. However, that does not necessarily mean that both parts are satisfied with it. *Punctuality*, with no difference in perception between users and provider, has for example one of the lowest combined satisfaction scores of the attributes.

5.4.2 Interviews with PT service providers

This part presents summaries of the interviews with Sharon Plotzki, Lovisa Borgström and Lisa Nordberg, providing useful insights about PT service providers' perception of PT in Gothenburg city.

Interview with Borgström and Plotzki
Borgström and Plotzki expressed their thoughts on each attribute, but made it clear that some of the factors that were brought up in the interview were not in their area of expertise. Some attributes were discussed more deeply in the interview, such as *fare, punctuallity* and *service frequency*. As for *punctuality*, Västtrafik acknowledges that PT users consider it as as an important attribute. Consequently, it is an attribute which is important for them to continuously improve as it may be a determining factor for individuals opting for PT over private car usage. The ambition for Västtrafik is to maintain the timetables for every route, although the *punctuality* can be affected by many different factors, some of which Västtrafik can not regulate themselves. One management strategy that was discussed to mitigate these issues and improving the *punctuality* is for the transportation mode to take a different route with less road congestion. However, this often causes the *trip length* and *travel time* to be longer.

Another attribute that was brought up in connection to *punctuality* was *service frequency*. Borgström and Plotzki were united in their views on this attribute, explaining that increasing the frequency would further contribute to highly congested roads, making the *punctuality* more difficult to control. They also said that increasing the frequency would be costly if the demand for more vehicles is too low. If it is hard to compromise between the *punctuality* and *service frequency*, Västtrafik look at other solutions, such as larger vehicles or changes in line routes. They have no goal in itself to increase the *service frequency*, as long as all the customers waiting for a vehicle are able to board it. This affects the way they view *crowding on board*, as Västtrafik from an economic and logistic standpoint are not able to motivate minimising the *crowding on board*, if the expense of other attributes as a result becomes too big. In many cases, an increased amount of *comfort* on the vehicles would for example directly translate to less capacity. This would interfere with Västtrafik's purpose and goals, as fewer people would be able to use their service.

As for *fare*, they made it clear that Västtrafik does not have the authority of deciding the ticket price. Instead it is Västra Götalands regionen (VGR) that makes those decisions. Therefore, the ticket price is not something that they actively work on. However, they are aware that the price is an important factor for their customers' satisfaction. In that regard, Borgström and Plotzki specifically mentioned that customers might not be aware that 50% of the PT costs are subsidized by VGR, and that knowing this information may

change their perception of the price. As Västtrafik knows the real cost of their service, they do not view the *fare* as too high. Furthermore, Borgström and Plotzki told us about results from previous studies where the ticket price had been reduced to zero, and that the result from such actions mostly made cyclists and walkers change to PT and that the amount of car users remained somewhat intact. Nevertheless, Västtrafik still put in effort in affecting the experience for the customer regarding the ticket price for the better. It is for example possible for companies to pay for their workers PT tickets. One other aspect to the ticket price is the amount of time a ticket is valid. In that regard, Borgström and Plotzki told us that Västtrafik give recommendations to VGR. Västtrafik explains on their website that if there were to exist a cheaper ticket with reduced duration time, more short trips would be made and would therefore depend on them being able to put even more buses and trams on the roads (Västtrafik, n.d.-b). This would increase the crowdedness and stress on the PT system even further. Furthermore, the new vehicles would also be of less economic value for Västtrafik in comparison to the already existing ones, as the demand for them are lower. According to Plotzki and Borgström, this makes Västtrafik less interested and able to make such investments.

Interview with Nordberg

In alignment with Bersgström and Plotzki, Nordberg also stated that Västtrafik is not in power of the *fare*. It was for example a political decision not to include a discount for students at one way tickets and only having a discount on period tickets. Consequently, she stated that they have not been working with the aim of lowering the ticket prices, rather working on improving their service in other areas. Nordberg also discussed the proposed idea of introducing a new cheaper ticket type with shorter duration. It was of her opinion that having two ticket types with different time duration co-exist would lead to difficulties in today's system. Nordberg explained that Västtrafik has a rule that says that if you enter a vehicle with a valid ticket, you can continue to travel in the vehicle for as long as you want, even if the ticket's time validation would run out. Having one short and one long ticket type available for the travellers would interfere with the simplicity of this rule and would maybe force Västtrafik to remove the rule and start checking traveller's tickets on their way out of the vehicles as well as on their way in. According to Nordberg, if some tickets were to be made cheaper, for example the one way ticket, it would result in Västtrafik being forced to raise the price on other tickets, such as the period tickets. Västtrafik would also not want to make adjustments of the ticket price that would go against their aim of benefiting frequent travellers as well as people travelling longer distances rather than shorter ones. Nordberg believes that the PT system is designed to serve as a car substitute rather than an option for walking or cycling. This could change if the ticket types changed.

6 Discussion

In this section, results are discussed, policy implications are presented, and limitations of the study are highlighted.

6.1 Discussion and policy implications of improvement attributes

Several valuable insights were drawn from the results of the study. It was interesting to note that for the overall sample as well for the sub-sample of car access and no car access, none of the basic factors fall under "Concentrate here". However, among the performance factors, *punctuality* and *fare* are the two common sets of attributes that fall under "Concentrate here" of the management scheme for the overall sample and the sub-samples. This shows that these attributes are of high importance to users but are associated with the least satisfaction. In the current scenario for a 90-minute trip, the fare of PT usage is 36 SEK, which is perceived as substantially high among consumers. Therefore, an important policy recommendation to transport planners and service providers is to lay an added emphasis on lowering the *fare* and improving *punctuality* of service to encourage its higher patronage. Among consumers with access to a car, in addition to *fare* and *punctuality*; *service frequency*, *travel time* and *number of transfer* are other important performance factors grouped under the management scheme "Concentrate here". Hence, it is imperative to focus on improving these attributes to attract consumers with access to a car to shift towards PT service usage in Gothenburg city. Among the excitement factors, *comfort* is observed as the attribute with high importance and low satisfaction among overall sample, indicating that improvement of *comfort* quality on-board may further increase appeal of PT services among consumers.

While investigating variation in consumer perception for PT services based on sociodemographic characteristics, it was interesting to note that there is no significant difference in the RIDIT ranking of importance of the PT attributes among the different groups. This means that the different sociodemographic sub-groups have a similar perception on the importance of the different attributes. However, regarding the RIDIT ranking of satisfaction there is a significant difference between the sociodemographic sub-groups, with exception to gender.

Fare was the attribute that had the worst performance rate between all the sociodemographic groups. As presented in table 11, all groups rank *fare* high, indicating low satisfaction. This means that in order to increase the OCS, this attribute should be improved. The only sociodemographic group that stood out in the ranking of *fare* was people with an income higher than the median. This group ranked *fare* as number 8, in contrast to people with income lower than the median who ranked it as number 1. This result indicates that for people with higher income, the price of PT is not as important to

prioritise for them to be more satisfied. They place greater emphasis on factors such as *comfort*, *cleanliness* and *stop illumination*, which could influence their perception of the service more. Additionally, this group's financial capacity might allow them to absorb higher ticket price more easily, making it a less decisive factor in their OCS with the service. A policy implication for a reduced ticket price will therefore have less impact on the satisfaction of people with an income above the median.

As for *punctuality* the RIDIT ranking does not vary between the sub-groups. The exception is the PT user frequency, where frequent PT users rank the attribute higher and their counterpart rank the attribute significantly lower. A possible explanation for this could be that infrequent users may travel for a specific purpose, thus depending on the PT to be punctual. Frequent PT users may be aware of regular small delays in the PT system and can therefore take those into consideration when planning a trip, resulting in less stressful situations and higher satisfaction. Improvement in *punctuality* performance of PT services may attract more infrequent users to choose PT as a mode. Furthermore, the result of the RIDIT analysis regarding *service frequency* shows that the perception varies between the different sub-groups. The groups with a significant difference are age and income. Young people and people with income below the median ranked the attribute higher possibly because they are more likely to be dependent on PT. These groups, who mostly consist of students, tend to use PT more often, and it would be more beneficial for them to have a higher *service frequency*. Their counterparts use PT less and most likely for a specific purpose, resulting in a lower demand for high *service frequency*. Increasing the *service frequency* may attract younger people and people with an income below the median to choose PT services for travel.

The RIDIT analysis for *travel time* varies substantially for each sub-group. Older people, infrequent users and people with an income above the median are generally more satisfied with the *travel time*, while their counterparts are not as satisfied. The possible explanation for this could be that the groups that ranked the attribute higher, indicating lower satisfaction, tend to use the PT more. This likely results in more negative experiences such as delays and disruptions, which means that if service providers were to prioritise *travel time* it would increase their OCS. A policy implication regarding *travel time* should attract both young people and people with income below the median. Regarding *number of transfers*, the rank varies substantially within the sub-groups, with exception for age. The rank is lower for infrequent PT users and for people with income above the median, while it is higher for their counterparts who are less satisfied with that attribute. As mentioned above, the explanation for this could be that the groups using PT more often have more negative experiences regarding *number of transfers*. A policy implication regarding *number of transfers* should attract infrequent travellers and people with income above the median.

As seen in table 12 the gap of perceived satisfaction among different attributes varies between service users and service providers. For some factors the service providers are more satisfied than PT users, while for other factors the PT users are more satisfied. However, for most of the attributes, the PT users and service providers have a similar perception regarding the satisfaction of the attributes. One attribute where there is no existing gap is *punctuality*, meaning that Västtrafik and the service users have aligned perceptions. Plotzki and Borgström from Västtrafik also stated that *punctuality* is an area that needs to be improved and that they are currently working towards achieving this. The perception of service providers and users aligning indicates good conditions for future possible policy implication, which would result in increased OCS. One gap where the service providers have a lower level of satisfaction compared to the PT users is *stop illumination*. This aligns well with the management scheme presented in figure 5, where this attribute falls under "Possible overkill". The gap can be the reason for the attribute being in this category. Some resources invested into this area can be reinvested into other more important attributes, which would have a bigger influence on the OCS.

The two attributes with the largest gap are *fare* and *crowding on board*. One reason for the gap regarding *crowding on board* could be that, as Plotzki and Borgström explained, Västtrafik prioritise that all passenger waiting at a stop will access the vehicle and not leave passengers behind because of too high levels of crowding. For them, this can be done at the expense of users having to travel in crowded conditions. On the contrary, PT users may value lower levels of crowding more to increase OCS. The largest gap is regarding the perception of *fare*. For PT users the ticket price seems unreasonably high, and is therefore a major source for dissatisfaction among all user groups. Västtrafik, however, claims to have a limited impact over *fare*, as this is decided by the Västra Götalandsregionen (VGR). Västtrafik's total revenues together with subsidises from the region decide the valid ticket price, in order for Västtrafik to be able to continue its services. The reason for the service providers having a higher level of satisfaction may be because they are not in control of the price, as well as them knowing all their exact expenses making the price more reasonable for them. Another possible reason for the large gap is the fact that Västtrafik, stated by Nordberg, have not been actively working towards reducing the *fare*, and rather focusing on other important attributes. To reduce the gap between the service providers and the PT users and increase the OCS, it is an important policy implication for transport planners and policy makers to reduce the price. This could further retain and attract new PT users.

6.2 Limitations of the study

A limitation of the study is the respondent group's representation of the society in zone A. As seen in table 4, many of the groups have different distributions. The amount of people using PT as the main source of travelling mode is 21 percentage units more in this study.

This has affected the distribution of several other sociodemographic groups. One of them is females, where in this study they were almost 15 percentage units higher than in the data about Gothenburg. However, the data from VGR, 2022, shows that women are more frequent users of the PT system compared to men, and since the data collection method led to more answers being collected from PT users, naturally more women have answered compared to men. This argument also applies to young people, students and people with a lower income, since these groups also tend to use the PT in higher frequencies, as per Västra Götalandsregionen, 2023. Because the data primarily comes from people using PT as a main transportation mode, the study emphasises the perspective of frequent PT users. Consequently, their viewpoints have a greater significance within the research framework. This alignment proves to be beneficial to the report's objectives, which specially focuses on the consumer's perception rather than those of the broader public.

Another limitation is the division of the revised IPA matrix. The matrix was divided into the two-dimensional grid using the mean value of the attribute's performance and derived importance. The placement of the axes can be done in different ways, which would likely result in some attributes being in different quadrants, especially since many of the attributes are adjacent to the axes in the results. Using a clustering method may have been a more suitable and accurate method of determining the placement of the axes of the revised IPA matrix.

7 Conclusion

This study has identified strategies for improvement of public transport services in Gothenburg zone A by a thorough data collection from both service users and the service provider. It was found that the priority areas of improvement in public transport services, based on consumer importance and satisfaction, are *punctuality*, *fare* and *number of transfers*. In addition to these attributes, *service frequency* and *travel time* are specific areas of improvement for people with access to a car. Policy implications regarding these areas can therefore be beneficial to encourage a shift from passenger car ownership towards PT usage. The consumers' satisfaction varies among the majority of the investigated sociodemographic characteristics, where the largest difference was found between people with higher and lower income. This report also shows the gaps between consumers' and the service provider's perception of the PT services, a main gap being their disparate views on the *fare*. The findings and insights of this study contributes to further improvements in the service of the PT system in Gothenburg, working as a basis for the policy and decision makers to use for their advantage. Although the results are case specific, the findings from the present study are expected to be of interest to transport planners and policymakers in other developed and developing countries, who are trying to promote PT services in larger cities to reduce vehicular emission and congestion in urban areas.

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A English questionnaire

See next page.

Dear Respondents,
Chalmers University of Technology is conducting research towards identifying strategies for improvement of public transport services in Gothenburg, Sweden. To carry out this research, it is important to know your perceptions towards various attributes associated with such services.
We shall be thankful to you for spending a little part of your precious time filling the questionnaire.
The survey will not collect any information that will identify you and hence protects your confidentiality. All the information provided will be strictly used for scholarly purposes only.
The survey is aimed at travelers within zone A.

Part A: Trip Characteristics

How frequently do you make trip (two-way) by any mode in a week?

- ◯ Less than 1 time
- ◯ 1-2 times
- ◯ 3-4 times
- ◯ 5-6 times
- ◯ 7 times or more

Predominantly used mode for travel:

- ◯ Bus
- ◯ Tram
- ◯ Car
- ◯ Two-wheeler
- ◯ Bicycle/E-bike/E-scooter
- ◯ Other: _____

Out of bus and tram - what is your predominantly used service?

- ◯ Bus
- ◯ Tram

You should base your answers on this mode of transportation for upcoming questions.

How frequently do you use your predominantly used public transport service (bus or tram) for making trips within the city (zone A), per week?

- ◯ Less than 1 time
- ◯ 1-2 times
- ◯ 3-4 times
- ◯ 5-6 times
- ◯ 7 times or more

Trip purpose for the most recent trip using predominantly used service:

- ◯ Work
- ◯ Business
- ◯ Education
- ◯ Recreation
- ◯ Others

What is your predominantly used ticket type?

- ◯ One-time ticket
- ◯ Day ticket
- ◯ Period ticket

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Part B: Importance of Attributes

In your opinion, how **IMPORTANT** are the following factors regarding your predominantly used public transport service?

	Not important at all				Very important
Before travel	1	2	3	4	5
Punctuality: Consistent and timely adherence to scheduled departure and arrival times.	◯	◯	◯	◯	◯
Service frequency: Time interval of vehicle availability along a particular route.	◯	◯	◯	◯	◯
Fare: Amount of money required to be paid for using the service	◯	◯	◯	◯	◯
Operation hours: Time duration for which the service is operational during a day along a route/route segment.	◯	◯	◯	◯	◯
Information on mobile app: Digital platform providing real-time and relevant data, updates, or details catering to trip maker's needs, or inquiries through mobile application interface.	◯	◯	◯	◯	◯
Ticketing system: Type of ticketing system i.e., on-board, off-board and online ticketing.	◯	◯	◯	◯	◯
During travel					
In-vehicle travel time: Total time spent inside a vehicle during a journey.	◯	◯	◯	◯	◯
Cleanliness: Maintenance of dirt-free and orderly environment inside the vehicle.	◯	◯	◯	◯	◯
Crowding on board: Degree of crowding when traveling. For example seat availability, or experience when standing in crowded conditions.	◯	◯	◯	◯	◯
Comfort: Degree of comfort experienced while traveling in a vehicle. For example, comfort in terms of occupying a seat, standing, on-board noise, vehicle temperature.	◯	◯	◯	◯	◯
On-board information: Real-time details and updates provided inside service vehicle during the journey, including route information, schedules, announcements, etc.	◯	◯	◯	◯	◯
Seating capacity: Maximum number of passengers the vehicle can accommodate with designated seating arrangements.	◯	◯	◯	◯	◯
Ease of boarding and alighting: Convenience of getting on and off the vehicle.	◯	◯	◯	◯	◯

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	Not important at all				Very important
At stop	1	2	3	4	5
Transfer time: Total time taken for transfer from one service to another to reach destination, which includes walking from one service stop to another and waiting for the next service.	◯	◯	◯	◯	◯
Number of transfers: Total number of changes from one service to another before reaching the destination.	◯	◯	◯	◯	◯
Access and egress time: Time taken to reach service stop from home and from service stop to the destination.	◯	◯	◯	◯	◯
Information at stop: Information available to the trip makers at the service stop, encompassing routes, schedule, delays, etc.	◯	◯	◯	◯	◯
Stop illumination: Provision of lighting at designated stops to enhance visibility during low- light conditions.	◯	◯	◯	◯	◯
Safety and security					
Safety on board: Precautions to reduce the risk of exposure to injury or danger during the event of an accident.	◯	◯	◯	◯	◯
Security: Measures ensuring protection against any form of danger or theft, within the vehicle, and at the stop.	◯	◯	◯	◯	◯

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Part C: Satisfaction of Attributes

How **SATISFIED** are you the following factors regarding your predominantly used public transport service?

	Not satisfied at all		Neutral		Very satisfied
Before travel	1	2	3	4	5
Punctuality: Consistent and timely adherence to scheduled departure and arrival times.	◯	◯	◯	◯	◯
Service frequency: Time interval of vehicle availability along a particular route.	◯	◯	◯	◯	◯
Fare: Amount of money required to be paid for using the service	◯	◯	◯	◯	◯
Operation hours: Time duration for which the service is operational during a day along a route/route segment.	◯	◯	◯	◯	◯
Information on mobile app: Digital platform providing real-time and relevant data, updates, or details catering to trip maker's needs, or inquiries through mobile application interface.	◯	◯	◯	◯	◯
Ticketing system: Type of ticketing system i.e., on-board, off-board and online ticketing.	◯	◯	◯	◯	◯
During travel					
In-vehicle travel time: Total time spent inside a vehicle during a journey.	◯	◯	◯	◯	◯
Cleanliness: Maintenance of dirt-free and orderly environment inside the vehicle.	◯	◯	◯	◯	◯
Crowding on board: Degree of crowding when traveling. For example seat availability, or experience when standing in crowded conditions.	◯	◯	◯	◯	◯
Comfort: Degree of comfort experienced while traveling in a vehicle. For example, comfort in terms of occupying a seat, standing, on-board noise, vehicle temperature.	◯	◯	◯	◯	◯
On-board information: Real-time details and updates provided inside service vehicle during the journey, including route information, schedules, announcements, etc.	◯	◯	◯	◯	◯
Seating capacity: Maximum number of passengers the vehicle can accommodate with designated seating arrangements.	◯	◯	◯	◯	◯
Ease of boarding and alighting: Convenience of getting on and off the vehicle.	◯	◯	◯	◯	◯

Turn page

At stop	Not satisfied at all 1	2	Neutral 3	4	Very satisfied 5
Transfer time: Total time taken for transfer from one service to another to reach the destination, which includes walking from one service stop to another and waiting for the next service.	◯	◯	◯	◯	◯
Number of transfers: Total number of changes from one service to another before reaching the destination.	◯	◯	◯	◯	◯
Access and egress time: Time taken to reach service stop from home and from service stop to the destination.	◯	◯	◯	◯	◯
Information at stop: Information available to the trip makers at the service stop, encompassing routes, schedule, delays, etc.	◯	◯	◯	◯	◯
Stop illumination: Provision of lighting at designated stops to enhance visibility during low- light conditions.	◯	◯	◯	◯	◯
Safety and security					
Safety on board: Precautions to reduce the risk of exposure to injury or danger during the event of an accident.	◯	◯	◯	◯	◯
Security: Measures ensuring protection against any form of danger or theft, within the vehicle, and at the stop.	◯	◯	◯	◯	◯

Overall Satisfaction	Not satisfied at all 1	2	Neutral 3	4	Very satisfied 5
What is your **overall level of satisfaction** regarding your predominantly used public transport service?	◯	◯	◯	◯	◯

Part D: Recent trip information

The following questions are about your most recent one-way trip.

Trip route: Write your recent trip route from start to end stop including transfer stops (eg. Korsvägen - Brunnsparken - Järntorget).

Answer: _____

Access time: Time taken to reach the service stop from destination.

Answer: _____

Crowding on board: Rate the level of crowding on board.

◯ Low crowding ◯ Moderate crowding ◯ High crowding ◯ Severe crowding

Time of travel: What time of day was your recent trip? (eg. 4 PM)

Answer: _____

Turn page

Part D: Sociodemographic Characteristics

The following part is about sociodemographic information. The survey will not collect any information that will identify you and hence protects your confidentiality. All the information provided will be strictly used for scholarly purposes only.

Gender?

◯ Male ◯ Female ◯ Other ◯ I do not want to answer

Age?

◯ ≤ 20 ◯ 21-35 ◯ 36-50 ◯ 51-65 ◯ > 65

Mark your highest finished education level.

◯ Elementary + middle school

◯ Upper secondary school

◯ Bachelor

◯ Master/doctor

Monthly income (SEK)?

◯ < 25 000

◯ 25 000 - 35 000

◯ 35 000 - 55 000

◯ > 55 000

Occupation?

◯ Working

◯ Student

◯ Retired

◯ Unemployed

◯ Other

Number of cars in your household:

◯ 0 ◯ 1 ◯ ≥ 2

If you have access to a car, what type?

◯ Fossilfuel-based

◯ Electric/hybrid

◯ I do not have access to a car

Do you have anything you would like to add about the public transportation system in Gothenburg?

Answer: _____

_____

_____

Thank you for taking your time answering our survey, we hope you have a continued nice day!

B Swedish questionnarie

See next page.

Chalmers tekniska högskola utför en undersökning för att identifiera strategier för förbättringar i kollektivtrafiken i Göteborg. För att göra undersökningen är det viktigt att veta dina uppfattningar om olika faktorer accocierade med kollektivtrafiken.

Vi är mycket tacksamma för att du spenderar en del av din tid till att fylla i enkäten!

Undersökningen samlar inte in någon information som kan identifiera dig och skyddar din integritet. All information insamlad kommer endast användas i vetenskapligt syfte. **Enkäten riktar sig mot resenärer i Zon A.**

Följande frågor handlar om ditt sätt att resa på.

Hur ofta reser du tur och retur, med valfritt transportmedel, per vecka?

- ◯ Mindre än 1 gång
- ◯ 1-2 gånger
- ◯ 3-4 gånger
- ◯ 5-6 gånger
- ◯ 7 gånger eller mer

Vilket är ditt främsta transportmedel?

- ◯ Buss
- ◯ Spårvagn
- ◯ Bil
- ◯ Tvåhjulsfordon (moped, motorcykel m.m.)
- ◯ Cykel/Elcykel/Elsparkcykel
- ◯ Annat: _____

Av buss och spårvagn - vilken form av kollektivtrafiktjänst använder du mest?

- ◯ Buss
- ◯ Spårvagn

Utgå från den kollektivtrafiktjänst du använder mest när du besvarar kommande frågor.

Hur ofta reser du med den kollektivtrafiktjänst du använder mest i zon A, per vecka?

- ◯ Mindre än 1 gång
- ◯ 1-2 gånger
- ◯ 3-4 gånger
- ◯ 5-6 gånger
- ◯ 7 gånger eller mer

Vad var syftet med den senaste resan du gjorde, med den kollektivtrafiktjänst du använder mest?

- ◯ Arbete
- ◯ Affärsresa
- ◯ Utbildning
- ◯ Fritid
- ◯ Annat

Vilken typ av biljett använder du mest?

- ◯ Enkelbiljett
- ◯ Dygnsbiljett
- ◯ Periodbiljett

Vänd blad

Hur **VIKTIGA** är följande faktorer gällande den kollektivtrafiktjänst du använder mest?

	Inte viktigt alls				Mycket viktigt
Inför resan	1	2	3	4	5
Punktlighet: Kollektivtrafiken är konsistent med att följa deras avsatta tider för avgång och ankomst.	○	○	○	○	○
Linjefrekvens: Hur ofta kollektivtrafiktjänsten avgår från en hållplats.	○	○	○	○	○
Biljettpris: Hur mycket det kostar för att nyttja Göteborgs kollektivtrafik en avsedd tid.	○	○	○	○	○
Servicespann: Hur länge på dygnet som fordonet är tillgängligt, d.v.s tiden som fordonet kör under en dag längs en rutt. Det finns exempelvis rutter som slutar att åka under natten.	○	○	○	○	○
Information i mobilappen: Mobilappen tillhandahåller realtids- och relevant information samt uppdateringar och detaljer om resan, som tillgodoser resenärens behov.	○	○	○	○	○
Biljettsystem: System för biljettförsäljning, exempelvis ombord, på hållplats, i butik, online osv.	○	○	○	○	○
Under resan					
Transporttid: Tiden det tar att transportera sig med kollektivtrafiktjänsten en given sträcka.	○	○	○	○	○
Renlighet: Skötsel och underhåll av ren och välordnad miljö inuti fordonet.	○	○	○	○	○
Trängsel ombord: Graden av trängsel vid resa. Till exempel platstillgänglighet, eller upplevelse när du står i trånga förhållanden.	○	○	○	○	○
Bekvämlighet: Graden av bekvämlighet som upplevs ombord på fordonet under resan. Exempelvis komfort på en sittplats, ståplats, ljudnivån ombord, fordonstemperatur.	○	○	○	○	○
Information ombord: Information och uppdateringar inuti fordonet under resan. Detta inkluderar exempelvis förändringar kring rutten eller meddelanden.	○	○	○	○	○
Sittkapacitet: Maximalt antal resenärer som fordonet kan ta emot med avsedda sittplatser.	○	○	○	○	○
På- och avstigning: Enkelhet att kliva på och av fordonet.	○	○	○	○	○

Vänd blad

	Inte viktigt alls				Mycket viktigt
Hållplats	1	2	3	4	5
Bytestid: Totala tiden det tar för att genomföra ett byte från ett kollektivfordon till ett annat, för att nå slutdestination. Detta inkluderar både tiden att gå från en hållplats till en annan samt väntetiden därimellan.	◯	◯	◯	◯	◯
Antal byten: Totalt antal byten från ett kollektivfordon till ett annat innan slutdestationen nås.	◯	◯	◯	◯	◯
Tillgänglighet och tid till hållplats: Tiden det tar att ta sig från startdestination till hållplatsen, samt från avstigning vid hållplats till slutdestination	◯	◯	◯	◯	◯
Information vid hållplatser: Tillgänglig information för resenärerna vid hållplatserna. Detta omfattar ruttinformation, tidtabeller, förseningar osv.	◯	◯	◯	◯	◯
Belysning vid hållplats: Tillhandahållandet av belysning vid avsedda hållplatser för att förbättra sikten vid svagt ljus.	◯	◯	◯	◯	◯
Säkerhet					
Trafiksäkerhet på kollektivfordon: Försiktighetsåtgärder för att minimera risken för skada eller fara vid eventuell trafikolycka.	◯	◯	◯	◯	◯
Trygghet: Hur trygg en resenärer känner sig under resan och vid hållplatser. Trygg mot fara eller någon annan form av utsatthet.	◯	◯	◯	◯	◯

Vänd blad

Hur **NÖJD** är du med följande faktorer i gällande den kollektivtrafiktjänst du använder mest?

	Inte nöjd alls		Neutral		Mycket nöjd
Inför resan	1	2	3	4	5
Punktlighet: Kollektivtrafiken är konsistent med att följa deras avsatta tider för avgång och ankomst.	◯	◯	◯	◯	◯
Linjefrekvens: Hur ofta kollektivtrafiktjänsten avgår från en hållplats	◯	◯	◯	◯	◯
Biljettpris: Hur mycket det kostar för att nyttja Göteborgs kollektivtrafik en avsedd tid.	◯	◯	◯	◯	◯
Servicespann: Hur länge på dygnet som fordonet är tillgängligt, d.v.s tiden som fordonet kör under en dag längs en rutt. Det finns exempelvis rutter som slutar att åka under natten.	◯	◯	◯	◯	◯
Information i mobilappen: Mobilappen tillhandahåller realtids- och relevant information samt uppdateringar och detaljer om resan, som tillgodoser resenärens behov.	◯	◯	◯	◯	◯
Biljettsystem: System för biljettförsäljning, exempelvis ombord, på hållplats, i butik, online osv.	◯	◯	◯	◯	◯
Under resan					
Transporttid: Tiden det tar att transportera sig med kollektivtrafiktjänsten en given sträcka.	◯	◯	◯	◯	◯
Renlighet: Skötsel och underhåll av ren och välordnad miljö inuti fordonet.	◯	◯	◯	◯	◯
Trängsel ombord: Graden av trängsel vid resa. Till exempel platstillgänglighet, eller upplevelse när du står i trånga förhållanden.	◯	◯	◯	◯	◯
Bekvämlighet: Graden av bekvämlighet som upplevs ombord på fordonet under resan. Exempelvis komfort på en sittplats, ståplats, ljudnivån ombord, fordonstemperatur.	◯	◯	◯	◯	◯
Information ombord: Information och uppdateringar inuti fordonet under resan. Detta inkluderar exempelvis förändringar kring rutten eller meddelanden.	◯	◯	◯	◯	◯
Sittkapacitet: Maximalt antal resenärer som fordonet kan ta emot med avsedda sittplatser.	◯	◯	◯	◯	◯
På- och avstigning: Enkelhet att kliva på och av fordonet.	◯	◯	◯	◯	◯

Hållplats

	Inte nöjd alls 1	2	Neutral 3	4	Mycket nöjd 5
Bytestid: Totala tiden det tar för att genomföra ett byte från ett kollektivfordon till ett annat, för att nå slutdestination. Detta inkluderar både tiden att gå från en hållplats till en annan, samt väntetiden därimellan.	◯	◯	◯	◯	◯
Antal byten: Totalt antal byten från ett kollektivfordon till ett annat innan slutdestationen nås.	◯	◯	◯	◯	◯
Tillgänglighet och tid till hållplats: Tiden det tar att ta sig från startdestination till hållplatsen, samt från avstigning vid hållplats till slutdestination	◯	◯	◯	◯	◯
Information vid hållplatser: Tillgänglig information för resenärerna vid hållplatserna. Detta omfattar ruttinformation, tidtabeller, förseningar osv.	◯	◯	◯	◯	◯
Belysning vid hållplats: Tillhandahållandet av belysning vid avsedda hållplatser för att förbättra sikten vid svagt ljus.	◯	◯	◯	◯	◯

Säkerhet

Trafiksäkerhet på kollektivfordon: Försiktighetsåtgärder för att minimera risken för skada eller fara vid eventuell trafikolycka.	◯	◯	◯	◯	◯
Trygghet: Hur trygg en resenärer känner sig under resan och vid hållplatser. Trygg mot fara eller någon annan form av utsatthet.	◯	◯	◯	◯	◯

Sammanfattning

Följande fråga handlar om **din helhetsuppfattning** kring den kollektivtrafiktjänst du använder mest.

	Inte nöjd alls				Mycket nöjd
Hur **nöjd** är du överlag med den kollektivtrafiktjänst du använder mest?	◯	◯	◯	◯	◯

Information om din senaste resa

Följande frågor handlar om den **senaste** resan du gjorde. Detta är inte nödvändigtvis med den kollektivtrafiktjänst som du använder mest.

Resväg: Skriv din senaste resväg genom att skriva hållplatsernas namn på start- och slutdestination. Inkludera om det gjordes något byte. *Exempelvis: Sandarna - Domkyrkan - Chalmers.*

Svar: _____

Tid till hållplats: Hur lång tid tog det för dig att ta dig till hållplatsen?

Svar: _____

Trängsel: Hur var nivån på trängseln under din senaste resa?

◯ ◯ ◯ ◯

Låg trängsel — Hög trängsel

Tid: Vilken tid på dygnet gjorde du din senaste resa? *Exempelvis: ca 13.00*

Svar: _____

Vänd blad

Sociodemografisk information

Följande avsnitt handlar om sociodemografisk information. Undersökningen samlar inte in någon information som kan identifiera dig och skyddar din integritet. All information insamlad kommer endast användas i vetenskapligt syfte.

Kön?

◯ Man ◯ Kvinna ◯ Annat ◯ Jag vill inte svara

Ålder?

◯ ≤ 20 ◯ 21-35 ◯ 36-50 ◯ 51-65 ◯ > 65

Vilken är din högsta genomförda utbildningsnivå?

◯ Grundskola
◯ Gymnasium
◯ Yrkesexamen
◯ Kandidat
◯ Master/Doktor

Inkomst per månad (SEK)?

◯ < 25 000
◯ 25 000 - 35 000
◯ 35 000 - 55 000
◯ > 55 000

Vad är din primära sysselsättning?

◯ Arbetar
◯ Studerar
◯ Pensionerad
◯ Arbetslös
◯ Annat

Antal bilar i hushållet?

◯ 0 ◯ 1 ◯ ≥ 2

Om du har tillgång till bil, vilken typ av bil är det?

◯ Fossildriven bil
◯ Elbil/hybrid
◯ Har inte tillgång till bil

Finns det något mer du skulle vilja tillägga om kollektivtrafiken i Göteborg?

Svar:

Tack snälla för att du tog dig tiden att besvara enkäten,
Hoppas att du får en fortsatt fin dag!

C Questionnaire for service providers

See next page.

Hej!
Vi är en grupp studenter på Chalmers tekniska högskola som i vårt kandidatarbete undersöker möjliga förbättringsstrategier av kollektivtrafiken inom Zon A i Göteborg. Vi har tagit fram 20 st viktiga faktorer som influerar hur en resenär upplever kollektivtrafiken. Vi har samlat in svar från ca 700 resenärer, som använder er tjänst, om deras åsikter om dessa faktorer. Nu vill vi gärna höra hur ni på Västtrafik tänker kring samma faktorer.

Enkäten riktar sig till dig som är anställd av Västtrafik och tar ca 5 minuter att besvara. Om det är någon faktor du jobbar närmare med får du gärna motivera ditt svar.

Undersökningen är helt anonym. Redovisning av resultatet kommer att ske på gruppnivå och ingen person kommer kunna identifieras.

Vi är mycket tacksamma för att ni spenderar en del av er tid till att fylla i vår enkät!

Vad är din uppfattning kring hur **VIKTIGA** följande faktorer gällande buss- och/eller spårvagnstjänster är, för Västtrafik?

Inför resan

	Inte viktigt alls 1	2	3	4	Mycket viktigt 5
Punktlighet: Hur konsekvens kollektivtrafiken är med att följa deras avsatta tider för avgång och ankomst.	○	○	○	○	○
Linjefrekvens: Hur ofta buss och/eller spårvagn avgår från en hållplats.	○	○	○	○	○
Biljettpris: Hur mycket det kostar för att nyttja Göteborgs kollektivtrafik en avsedd tid.	○	○	○	○	○
Servicespann: Hur länge på dygnet som fordonet är tillgängligt, d.v.s tiden som fordonet kör under en dag längs en rutt. Det finns exempelvis rutter som slutar att åka under natten.	○	○	○	○	○
Information i mobilappen: Mobilappen tillhandahåller realtids- och relevant information samt uppdateringar och detaljer om resor, som tillgodoser resenärens behov.	○	○	○	○	○
Biljettsystem: System för biljettförsäljning (ombord, på hållplats, i butik, online osv.)	○	○	○	○	○

Motivera gärna dina svar: _____

_____

_____

_____

Under resan

	Inte viktigt alls 1	2	3	4	Mycket viktigt 5
Transporttid: Tiden det tar att transportera sig med buss och/ eller spårvagn en given sträcka.	○	○	○	○	○
Renlighet: Skötsel och underhåll av ren och välordnad miljö inuti fordonet.	○	○	○	○	○
Trängsel ombord: Graden av trängsel vid resa.	○	○	○	○	○

	Inte viktigt alls 1	2	3	4	Mycket viktigt 5
Bekvämlighet: Graden av bekvämlighet som upplevs ombord (komfort på en sittplats, ståplats, ljudnivån ombord, fordonstemperatur osv).	○	○	○	○	○
Information ombord: Information och uppdateringar inuti fordonet under resan (förändringar kring rutten eller andra meddelanden).	○	○	○	○	○
Sittkapacitet: Maximalt antal resenärer som fordonet kan ta emot med avsedda sittplatser.	○	○	○	○	○
På- och avstigning: Enkelhet att kliva på och av fordonet.	○	○	○	○	○

Motivera gärna dina svar: _____

Hållplats

	Inte viktigt alls 1	2	3	4	Mycket viktigt 5
Bytestid: Totala tiden det tar för att genomföra ett byte (tiden det tar att gå från en hållplats till en annan, samt väntetiden däremellan).	○	○	○	○	○
Antal byten: Totalt antal byten från en buss/spårvagn till en annan innan slutdestationen nås.	○	○	○	○	○
Tillgänglighet och tid till hållplats: Tiden det tar att ta sig från startdestination till hållplatsen, samt från avstigning vid hållplats till slutdestination	○	○	○	○	○
Information vid hållplatser: Tillgänglig information för resenärerna vid hållplatserna (ruttinformation, tidtabeller, förseningar osv).	○	○	○	○	○
Belysning vid hållplats: Tillhandahållandet av belysning vid hållplatser för att förbättra sikten.	○	○	○	○	○

Motivera gärna dina svar: _____

Säkerhet

	Inte viktigt alls 1	2	3	4	Mycket viktigt 5
Trafiksäkerhet ombord: Försiktighetsåtgärder för att minimera risken för skada eller fara vid eventuell trafikolycka.	○	○	○	○	○
Trygghet: Hur trygg en känner sig under resan och vid hållplatser (upplevd trygghet mot fara eller någon annan form av utsatthet)	○	○	○	○	○

Motivera gärna dina svar: _____

Vad är din uppfattning kring hur **NÖJDA** Västtrafik är med följande faktorer gällande buss- och/eller spårvagnstjänster?

Inför resan

	Inte nöjd alls 1	2	Neutral 3	4	Mycket nöjd 5
Punktlighet: Hur konsekvent kollektivtrafiken är med att följa deras avsatta tider för avgång och ankomst.	○	○	○	○	○
Linjefrekvens: Hur ofta buss och/eller spårvagn avgår från en hållplats	○	○	○	○	○
Biljettpris: Hur mycket det kostar för att nyttja Göteborgs kollektivtrafik en avsedd tid.	○	○	○	○	○
Servicespann: Hur länge på dygnet som fordonet är tillgängligt, d.v.s tiden som fordonet kör under en dag längs en rutt (det finns exempelvis rutter som slutar att åka under natten).	○	○	○	○	○
Information i mobilappen: Mobilappen tillhandahåller realtids- och relevant information samt uppdateringar och detaljer om resor, som tillgodoser resenärens behov.	○	○	○	○	○
Biljettsystem: System för biljettförsäljning (ombord, på hållplats, i butik, online osv).	○	○	○	○	○

Motivera gärna dina svar: _____

_____

_____

_____

Under resan

	Inte nöjd alls 1	2	Neutral 3	4	Mycket nöjd 5
Transporttid: Tiden det tar att transportera sig med buss och/ eller spårvagn en given sträcka.	○	○	○	○	○
Renlighet: Skötsel och underhåll av ren och välordnad miljö inuti fordonet.	○	○	○	○	○
Trängsel ombord: Graden av trängsel vid resa.	○	○	○	○	○
Bekvämlighet: Graden av bekvämlighet som upplevs ombord (komfort på en sittplats, ståplats, ljudnivån ombord, fordonstemperatur, osv).	○	○	○	○	○
Information ombord: Information och uppdateringar inuti fordonet under resan (förändringar kring rutten eller andra meddelanden)	○	○	○	○	○
Sittkapacitet: Maximalt antal resenärer som fordonet kan ta emot med avsedda sittplatser.	○	○	○	○	○
På- och avstigning: Enkelhet att kliva på och av fordonet.	○	○	○	○	○

Motivera gärna dina svar: _____

_____

_____

_____

Hållplats

	Inte nöjd alls 1	2	Neutral 3	4	Mycket nöjd 5
Bytestid: Totala tiden det tar för att genomföra ett byte (både tiden det tar att gå från en hållplats till en annan, samt väntetiden däremellan).	○	○	○	○	○
Antal byten: Totalt antal byten från ett kollektivfordon till ett annat innan slutdestationen nås.	○	○	○	○	○
Tillgänglighet och tid till hållplats: Tiden det tar att ta sig från startdestination till hållplatsen, samt från avstigning vid hållplats till slutdestination	○	○	○	○	○
Information vid hållplatser: Tillgänglig information vid hållplatserna (ruttinformation, tidtabeller, förseningar osv).	○	○	○	○	○
Belysning vid hållplats: Tillhandahållandet av belysning vid hållplatser för att förbättra sikten.	○	○	○	○	○

Motivera gärna dina svar: _____

_____

_____

_____

Säkerhet

	Inte nöjd alls 1	2	Neutral 3	4	Mycket nöjd 5
Trafiksäkerhet på kollektivfordon: Försiktighetsåtgärder för att minimera risken för skada eller fara vid eventuell trafikolycka.	○	○	○	○	○
Trygghet: Hur trygg en känner sig under resan och vid hållplatser (upplevd trygghet mot fara eller någon annan form av utsatthet)	○	○	○	○	○

Motivera gärna dina svar: _____

_____

_____

_____

Sammanfattning

	Inte nöjd alls				Mycket nöjd
Hur **nöjda** är ni överlag med kollektivtrafiken i Göteborg (zon A)?	○	○	○	○	○

Motivera gärna ditt svar: _____

_____

_____

_____

D Interview questions for interview with Nordberg

- Vill du berätta om er affärsmodell? Vad är era största kostnader med kollektivtrafiken? Hur är resurserna fördelade (t.ex. efter trafikkostnader, lönekostnader, chaufförer, anställda osv)? Hur kommer det sig att priset ligger där det är idag?

- Enligt vår undersökning så är biljettpriset väldigt viktigt för resenärerna. Det är också något de inte är så nöjda med. Finns det lösningar ni jobbar på för att förbättra biljettpriset för resenärerna? Vad är svårigheterna? Var finns det utvecklingspotential?

- Hur går era tankar kring korttidsbiljetter? Vad ser ni som det positiva och negativa med detta? Vad är största möjligheten? Vad är största hindret?

- Hur ser ni kring att erbjuda studenter billigare alternativ på biljetter, till exempel studentrabatt på bland annat enkelbiljetter och inte bara periodbiljetter?

- Hur många resenärer vill ni optimalt ha? Vad påverkar hur många resenärer ni kan ha? Har ni en maximal gräns?

- Har ni några tillväxtmål/ekonomiska mål i företaget?

- I dagsläget, hur nöjd är du med priset?

E Python-code for revised IPA

```
1
2  import pandas as pd
3  import numpy as np
4  import matplotlib.pyplot as plt
5  import skfuzzy as fuzz
6  import cycler
7
8  data = pd.read_csv('/Users/idakron/Documents/Kandidatarbete/data.csv',
       delimiter=',')
9
10 derived_importance = data['DI normalized'].str.replace(',', '.').astype
       (float)
11 performance = data['SM normalized'].str.replace(',', '.').astype(float)
12 stated_importance = data['SI normalized'].str.replace(',', '.').astype(
       float)
13
14 #%% all attributes
15
16 plt.figure(1)
17 plt.scatter(derived_importance, performance, alpha = 0.5)
18 plt.axvline(x = 0.536, color = 'k')
19 plt.axhline(y=0.567, color='k')
20 plt.ylim(0.15,0.8)
21 plt.xlabel('Derived importance')
22 plt.ylabel('Performance')
23 plt.title('Revised Importance-Performance Analysis')
24
25 numbers = ['1', '2', '3', '4', '5', '6', '7', '8', '9', '10', '11', '12
       ', '13', '14', '15', '16', '17', '18', '19', '20']
26
27 for xi, yi, num in zip(derived_importance, performance, numbers):
28     plt.text(xi, yi, str(num), fontsize=9, ha='right')
29
30
31 plt.figure(2)
32 plt.scatter(stated_importance, derived_importance, alpha= 0.5)
33 plt.axvline(x = 0.792, color = 'k')
34 plt.axhline(y=0.536, color='k')
35 plt.xlim(0.5,1)
36 plt.ylim(0.4,0.7)
37 plt.xlabel('Stated Importance')
38 plt.ylabel('Derived Importance')
39 plt.title('Revised Importance-Performance Analysis')
40
41 for xi, yi, num in zip(stated_importance, derived_importance, numbers):
42     plt.text(xi, yi, str(num), fontsize=9, ha='right')
```

```
43
44 #%% car owners
45
46 plt.figure(1)
47 plt.scatter(derived_importance, performance, alpha = 0.5)
48 plt.axvline(x = 0.536, color = 'k')
49 plt.axhline(y=0.539, color='k')
50 plt.ylim(0.15,0.8)
51 plt.xlabel('Derived importance')
52 plt.ylabel('Performance')
53 plt.title('Revised IPA - Car owners')
54
55 numbers = ['1', '2', '3', '4', '5', '6', '7', '8', '9', '10', '11', '12
    ', '13', '14', '15', '16', '17', '18', '19', '20']
56
57 for xi, yi, num in zip(derived_importance, performance, numbers):
58     plt.text(xi, yi, str(num), fontsize=9, ha='right')
59
60
61 plt.figure(2)
62 plt.scatter(stated_importance, derived_importance, alpha= 0.5)
63 plt.axvline(x = 0.8, color = 'k')
64 plt.axhline(y=0.536, color='k')
65 plt.xlim(0.5,1)
66 plt.ylim(0.4,0.7)
67 plt.xlabel('Stated Importance')
68 plt.ylabel('Derived Importance')
69 plt.title('Revised IPA - Car owners')
70
71 for xi, yi, num in zip(stated_importance, derived_importance, numbers):
72     plt.text(xi, yi, str(num), fontsize=9, ha='right')
73
74 #%% non car owners
75
76 plt.figure(1)
77 plt.scatter(derived_importance, performance, alpha = 0.5)
78 plt.axvline(x = 0.527, color = 'k')
79 plt.axhline(y=0.586, color='k')
80 plt.ylim(0.15,0.8)
81 plt.xlabel('Derived importance')
82 plt.ylabel('Performance')
83 plt.title('Revised IPA - Non car owners')
84
85 numbers = ['1', '2', '3', '4', '5', '6', '7', '8', '9', '10', '11', '12
    ', '13', '14', '15', '16', '17', '18', '19', '20']
86
87 for xi, yi, num in zip(derived_importance, performance, numbers):
88     plt.text(xi, yi, str(num), fontsize=9, ha='right')
```

```
89
90
91  plt.figure(2)
92  plt.scatter(stated_importance, derived_importance, alpha= 0.5)
93  plt.axvline(x = 0.785, color = 'k')
94  plt.axhline(y=0.527, color='k')
95  plt.xlim(0.5,1)
96  plt.ylim(0.4,0.7)
97  plt.xlabel('Stated Importance')
98  plt.ylabel('Derived Importance')
99  plt.title('Revised IPA - Non car owners')
100
101 for xi, yi, num in zip(stated_importance, derived_importance, numbers):
102     plt.text(xi, yi, str(num), fontsize=9, ha='right')
```

F Python-code for RIDIT analysis

```
1
2  import pandas as pd
3  import numpy as np
4  import csv
5
6  # Load your dataset into a Pandas DataFrame
7  data = pd.read_csv('Attributes - Men.csv')
8
9  # List of variables for RIDIT analysis
10
11 importance_variables = ['I_Punctuality', 'I_Service_frequency', '
       I_Span_of_service',
12                          'I_Fare', 'I_Mobile_app', 'I_Ticketing_system',
        'I_Travel_time',
13                          'I_Cleanliness', 'I_Crowding_on_board', '
       I_Comfort',
14                          'I_On_board_information', 'I_Seating_Capacity',
15                          'I_Ease_of_boarding_and_alighting', '
       I_Transfer_time',
16                          'I_Number_of_transfers', '
       I_Accessibility_and_time_to_stop',
17                          'I_Information_at_stops', 'I_Stop_illumination'
       , 'I_safety_on_board',
18                          'I_Security']
19
20
21 # Dictionary to store RIDIT scores for each variable
22 ridit_scores_matrix_importance = {}
23
24
25 # Calculate RIDIT scores for each variable
26 for variable_name in importance_variables:
27     variable = data[variable_name]
28
29     # Calculate RIDIT scores for the selected variable
30     def calculate_ridit_scores(series):
31         n = len(series)
32         counts = series.value_counts().sort_index()
33         cumulative_proportions = counts.cumsum() / n
34         ridit_scores = (cumulative_proportions - 0.5) / (1 - 0.5)
35         return ridit_scores.reindex(series)
36
37     ridit_scores = calculate_ridit_scores(variable)
38
39     # Store RIDIT scores in the dictionary
40     ridit_scores_matrix_importance[variable_name] = ridit_scores.tolist
```

```
    ()
41
42
43 # Calculate average RIDIT score for each variable
44 average_ridit_scores_importence = {}
45 for variable, scores in ridit_scores_matrix_importance.items():
46     average_ridit_scores_importence[variable] = np.mean(scores)
47
48 # Rank the variables based on their average RIDIT scores
49 ranked_variables = sorted(average_ridit_scores_importence, key=
    average_ridit_scores_importence.get, reverse=True)
50
51 # Print the ranked variables
52 for rank, variable in enumerate(ranked_variables, start=1):
53     print(f"Rank {rank}: {variable} (Average RIDIT Score: {
    average_ridit_scores_importence[variable]})")
54
55
56 #%%
57
58 # Load your dataset into a Pandas DataFrame
59 data = pd.read_csv('Attributes - Men.csv')
60 satisfaction_variables = ['S_Punctuality', 'S_Service_frequency',
61                           'S_Span_of_service', 'S_Fare', 'S_Mobile_app
    ',
62                           'S_Ticketing_system', 'S_Travel_time', '
    S_Cleanliness',
63                           'S_Crowding_on_board', 'S_Comfort', '
    S_On_board_information',
64                           'S_Seating_capacity', '
    S_ease_of_boarding_and_alighting',
65                           'S_transfer_time', 'S_Number_of_transfers',
66                           'S_accessibility_and_time_to_stop', '
    S_information_at_stops',
67                           'S_stop_illumination', 'S_safety_on_board',
    'S_security']
68
69 ridit_scores_matrix_satisfaction = {}
70
71 # Calculate RIDIT scores for each variable
72 for variable_name in satisfaction_variables:
73     variable = data[variable_name]
74
75     # Calculate RIDIT scores for the selected variable
76     def calculate_ridit_scores(series):
77         n = len(series)
78         counts = series.value_counts().sort_index()
79         cumulative_proportions = counts.cumsum() / n
```

```
        ridit_scores = (cumulative_proportions - 0.5) / (1 - 0.5)
        return ridit_scores.reindex(series)

    ridit_scores = calculate_ridit_scores(variable)

    # Store RIDIT scores in the dictionary
    ridit_scores_matrix_satisfaction[variable_name] = ridit_scores.
    tolist()


# Calculate average RIDIT score for each variable
average_ridit_scores_satisfaction = {}
for variable, scores in ridit_scores_matrix_satisfaction.items():
    average_ridit_scores_satisfaction[variable] = np.mean(scores)

# Rank the variables based on their average RIDIT scores
ranked_variables = sorted(average_ridit_scores_satisfaction, key=
    average_ridit_scores_satisfaction.get, reverse=True)

# Print the ranked variables
for rank, variable in enumerate(ranked_variables, start=1):
    print(f"Rank {rank}: {variable} (Average RIDIT Score: {
    average_ridit_scores_satisfaction[variable]})")

#%%

importance_data = """
Attribute,M,F,Y,O,Fr,IFr,LI,HI,C,NC
Punctuality,7,6,6,7,6,7,6,7,6,6
Service frequency,4,5,5,4,4,5,5,1,5,5
Span of service,12,18,13,20,16,16,14,19,16,15
Fare,1,1,1,5,1,1,1,8,3,1
Comfort,13,17,16,17,18,14,16,17,18,13
Information in mobile app,2,3,3,1,2,3,3,2,1,3
Ticketing system,18,16,18,14,19,15,19,16,17,17
Travel time,6,8,7,6,7,6,8,5,7,7
Cleanliness,11,4,10,16,11,11,10,11,14,10
Crowding on board,14,14,15,15,13,17,15,14,15,14
On-board information,16,10,12,12,10,12,12,12,12,11
Seating capacity,15,19,17,18,17,19,18,18,19,18
Ease of boarding,20,20,20,19,20,20,20,20,20,20
Transfer time,10,12,11,13,12,10,11,9,10,12
Number of transfers,9,9,9,8,9,8,9,6,8,9
Accessibility,8,7,8,10,8,9,7,10,9,8
Info at stop,17,15,19,9,15,18,17,15,13,19
Stop Illumination,19,11,3,11,14,13,13,13,11,16
Safety,5,4,4,3,5,4,4,3,4,4
Security,3,2,2,2,3,2,2,4,2,2
```

```
"""

# Split the data into rows
rows = [row.split(',') for row in importance_data.strip().split('\n')]

# Transpose rows to get columns
columns = zip(*rows)

# Write data to CSV file
with open('importance_data.csv', 'w', newline='') as csvfile:
    writer = csv.writer(csvfile)
    writer.writerows(columns)


# Read the CSV file
with open('importance_data.csv', 'r', newline='') as csvfile:
    reader = csv.reader(csvfile)

    # Transpose rows to get columns
    columns = zip(*reader)

# Write transposed data to a new CSV file
with open('transposed_importance_data.csv', 'w', newline='') as csvfile
    :
    writer = csv.writer(csvfile)

    # Write the transposed data
    writer.writerows(columns)

print("CSV file 'transposed_importance_data.csv' has been created with
    transposed data.")


#%%

satisfaction_data = """
Attribute,M,F,Y,O,Fr,IFr,LI,HI,C,NC
Punctuality,16,11,16,11,16,8,14,11,10,15
Service frequency,18,15,9,20,12,19,6,20,20,8
Span of service,10,18,18,9,11,17,12,15,12,16
Fare,2,1,1,1,1,1,1,8,2,1
Comfort,1,2,2,3,2,2,3,3,1,5
Information in mobile app,14,20,19,15,20,16,19,16,15,19
Ticketing system,20,19,20,17,19,20,20,13,16,20
Travel time,15,12,6,19,3,18,4,19,19,7
Cleanliness,7,4,10,2,7,5,8,2,3,9
Crowding on board,19,10,14,18,15,14,16,14,14,18
On-board information,13,16,15,12,17,9,17,9,9,14
```

```
Seating capacity,8,6,7,7,13,4,9,7,5,11
Ease of boarding,12,17,17,8,14,13,15,12,8,17
Transfer time,9,13,4,16,8,11,2,18,18,3
Number of transfers,17,8,12,10,10,15,7,17,17,6
Accessibility,4,9,5,13,6,10,10,10,11,4
Info at stop,11,14,11,14,18,6,18,4,13,13
Stop Illumination,3,3,3,4,5,3,5,1,4,2
Safety,6,5,8,6,4,12,11,6,6,10
Security,5,7,13,5,9,7,13,5,7,12
"""

# Split the data into rows
rows = [row.split(',') for row in satisfaction_data.strip().split('\n')]

# Transpose rows to get columns
columns = zip(*rows)

# Write data to CSV file
with open('satisfaction_data.csv', 'w', newline='') as csvfile:
    writer = csv.writer(csvfile)
    writer.writerows(columns)

# Read the CSV file
with open('satisfaction_data.csv', 'r', newline='') as csvfile:
    reader = csv.reader(csvfile)

    # Transpose rows to get columns
    columns = zip(*reader)

# Write transposed data to a new CSV file
with open('transposed_satisfaction_data.csv', 'w', newline='') as csvfile:
    writer = csv.writer(csvfile)

    # Write the transposed data
    writer.writerows(columns)

print("CSV file 'transposed_satisfaction_data.csv' has been created with transposed data.")
```