IDENTIFYING PRIORITY AREAS BASED ON A THIRTEEN YEARS EVOLUTION OF SATISFACTION WITH PUBLIC TRANSPORT AND ITS DETERMINANTS

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ABSTRACT

Measuring and analysing satisfaction with public transport services facilitates service performance monitoring, market analysis, benchmarking and the identification of priority areas. The systematic and regular collection of information concerning satisfaction enables to investigate how passengers’ satisfaction as well as its determinants changes over time. These changes may be driven by changes in service quality or shifts in passengers’ expectations and preferences. This study analyses how satisfaction with public transport and its determinants evolved over time in Sweden in the years 2001-2013. The determinants of satisfaction are identified based on a factor analysis and the estimation of multivariate satisfaction models. The superposition of our findings culminates in a dynamic passenger satisfaction priority map which allows identifying priority areas based on observed trends in satisfaction with service attributes and their respective importance. The deterioration of overall satisfaction with public transport in Sweden in recent years is driven by a decrease in satisfaction with customer interface and length of trip time. These two service aspects as well as the operation and network service aspects were found key determinants of overall satisfaction which users consistently rate among the least satisfactory. The results of this study are instrumental in supporting service providers in designing measures that will foster satisfaction in the future.
1. INTRODUCTION

Improving public transport (PT) services and attracting more travellers to shift from car to PT is a key policy area in many countries across the globe. There is a large body of knowledge in the management and marketing sciences on the influence of service quality and satisfaction on reputation, customer loyalty and ultimately future choices (see [1] for relevant references). Service quality is defined in a TCRP [2] as the ability to deliver service conforming to user expectations on a consistent basis. Service quality is hence defined in terms of the subjective evaluation made by service users. Lai and Chen demonstrated that satisfaction is a key determinant of future choices and loyalty also in the case of PT [3]. Failing to understand the factors that underlie passenger satisfaction and how they interact with service performance and improvements may therefore hinder the design of policies and strategies to improve service quality and attract new passengers [4].

Given the limited resources, it is essential to identify the main determinants of travel satisfaction with PT in order to prioritize the most effective measures and policies [5]. This has led to an increasing interest in recent years in systematically collecting and analysing data on users’ satisfaction and defining standard indicators to measure them. For example, the European Union commissioned a survey called the Eurobarometer on satisfaction with urban transport and performed a cross-European comparison and support policy making [6].

The comparison of satisfaction with service across countries or organizations can foster self-improvement through benchmarking against peer cities [7] or operators [8]. Moreover, monitor users’ satisfaction became an industry standard and is commonly used as one of the incentives in tendered PT contracts. In addition to surveys, methods to monitor satisfaction include interviewing focus groups, sending mystery shoppers and assembling user reviews. According to the gap analysis approach proposed in TCRP [9], satisfaction refers to the gap between expected and perceived service. This gap could however arise from other gaps such as discrepancies between service quality specifications (e.g. dispatching regulation) and service delivery (e.g. actual circulation at terminals).

Passengers’ satisfaction with PT services is expected to reflect volatility or systematic changes in the quality of the service delivered. Extreme negative events are expected to leave a lasting mark on how service is perceived [10]. Furthermore, even the underlying determinants of service satisfaction may shift over time. This presumably reflects changes in passengers’ expectations.

Measuring and analysing satisfaction with PT is thereof essential for service performance monitoring, market analysis, benchmarking and the identification of priority areas. Analysing survey results concerning satisfaction with PT service in Sweden in the years 2001-2013, this study considered the following research questions: (1) what are the main determinants of PT satisfaction? (2) Do these determinants remain stable over time? (3) How can service providers identify priority areas for improvement based on passengers’ satisfaction data? In order to address these issues, we first provide a review on how travel satisfaction is conceptualized, measured and previous findings on its underlying determinants (Section 2). Section 3 details the survey design and related analysis. The results of the analysis are then provided in Section 4 including cross-correlations, factor analysis and the estimation of multivariate service satisfaction models. The superposition of our findings culminates in a dynamic passenger satisfaction priority map. This paper concludes with suggestions for PT service providers and further research.
2. LITERATURE REVIEW OF PASSENGER SATISFACTION AND ITS DETERMINANTS

It is commonly postulated that providing a better PT service quality will lead to greater passengers’ overall satisfaction and subsequently to higher likelihood to use PT service more frequently [11]. However, previous studies suggest that an enhanced supply does not automatically lead to a corresponding increase in demand and satisfaction [12-13]. Chen [11] defined the satisfaction as an overall affective response to a perceived discrepancy between prior expectation and perceived performance after consumption. This can be further defined as the degree to which one believes that an experience evokes positive feelings [14]. In practice, service quality and satisfaction are often used interchangeably, because both are evaluation variables relating to consumers’ perceptions about a given product or service.

From stakeholders’ and operators’ perspectives, the satisfaction of customers, or in other words the extent to which organizations meet their customers’ expectations, is an important indicator of an organization’s success and sustainability [8]. This underlies the many efforts that have been made in the last decade to evaluate customer satisfaction with a clear focus on the quality of the service [e.g. 9,15] and identifying users’ priorities [e.g. 16-19]. Eboli and Mazzulla [20] argue that considering passenger perceptions is fundamental because the customer’s point of view is very relevant for evaluating the performance of a transit service. At the same time, deploying a more objective measurement by the transit agency can be instrumental in acquiring a more comprehensive service quality assessment.

A large number of aspects might be considered by PT authorities and operators when measuring passengers’ satisfaction, including comfort, value-for-money, punctuality etc. Hensher et al. [21] argue that although a passenger may perceive specific aspects of service quality as either positive or negative, it can be assumed that the overall level of passenger satisfaction is best measured by how an individual evaluates the total package of services offered. However, some of these aspects are expected to be more important than others. The importance attached to various quality of service attributes (QoSA) can be measured using stated preference surveys (which ask people how much they value a particular feature) and revealed preference studies (which evaluate the choices people actually make when facing trade-offs between various attributes).

The subjective nature of perceived service quality implies that it is subject to contextual and cognitive biases. Measurements of service quality based on reported satisfaction levels are therefore dependent on users’ expectations, social norms and retrieved situational awareness. It is therefore advisable to measure experienced utility instead of, or as a complement to, decision utility inferred from choices [22]. Without this knowledge, nobody knows whether there is a systematic discrepancy between these notions and which of them resonates in user’s perceptions. Dell’Olio et al. [23] found that bus users tend to be less critical towards variations in overall quality when stimulated into thinking more deeply about other influential variables.

Based on an experiment in eight European cities, METPEX [24] identified the key determinants of satisfaction on individual trip stages as well as the whole journey experience. They found that past experience and travellers’ expectations are key determinants of passenger experience, while travellers’ emotional state, attitudes and opinions concerning travel safety and particular travel modes played significant roles in influencing the reported travel satisfaction. In contrast, socio-demographic variables and trip characteristics were not found significant determinants of the overall level of satisfaction. Regarding PT service aspects, they concluded that the ease of transfer, station environment, service frequency and travel time reliability are the key determinants of travel satisfaction. In addition, safety while waiting is an important determinant for women travellers.
Different travelers using different travel modes have different needs and priorities, thus influencing their appreciation of and satisfaction with various QoSA. Susilo and Cats [18] found that service frequency and travel time reliability are important determinants of overall satisfaction for women and young travelers, while travel time reliability is also important for low-income or unemployed travelers.

As this review illustrates, a significant body of literature studies passenger satisfaction in a cross-section manner. However, satisfaction and what makes one satisfied also evolve over time. For example, services that once were perceived as innovative or fashionable may later on be taken as granted by passengers, whilst new technologies would create a new demand, such as in the contemporary case of internet access availability on-board [25,26]. Previous studies [27-29] found that satisfaction with daily travel in general differs significantly between urban areas of different scales and between socio-demographic groups, Thus, it is of utmost importance to understand how PT users’ satisfaction and its determinants evolve over time and derive its implications on priority areas for service providers.

3. METHODOLOGY AND SURVEY DESCRIPTIONS

The Swedish Public Transport Association (Svensk Kollektivtrafik) – a trade organization representing the regional PT agencies of the 21 Swedish counties - conducts since 2001 a rolling survey aimed to monitor developments in the PT market. Respondents are interviewed on a regular basis year-round. The results of the survey are summarized annually into a ‘Swedish Public Transport Barometer’ (SPTB) which provides an overview of satisfaction and attitudes towards PT across Sweden [30]. The analysis in this paper considers the dataset as a time-series from 2001 to 2013. The survey consists of four sections:

(a) Service and quality -

Overall satisfaction with PT and;

Satisfaction with the following QoSA:

- Customer interface (service provider’s responsiveness)
- Freedom from crime (risk perception, security)
- General information (ease of getting information on departures)
- Information on planned changes (with respect to routes and schedules)
- Information on unplanned services (with respect to delays)
- Length of trip time (speed, directness)
- Network (the suitability of PT lines to passenger’s needs)
- On-board conditions (cleanliness, vehicle design)
- Operations (service frequency and reliability)
- Ride comfort (seat availability and comfort)
- Staff and assistance (drivers’ and other staff friendliness)
- Ticket accessibility (ease of purchasing tickets)

(b) Brand - perceptions and attitudes towards PT and competing modes;

(c) Individual attributes - socio-demographic variables, travel habits;

(d) Market share - frequency of using various travel modes.

In the case of sections (a) and (b), respondents were asked to indicate their agreement with statements referring to satisfaction or perceptions on a Likert scale of: 1 (strongly disagree) to 5 (strongly agree). For example, one of the statements reads “It feels safe to travel by public transport” and thus the Likert scale corresponds to a scale ranging from very dissatisfied (1), rather dissatisfied (2), neither dissatisfied nor satisfied (3), fairly satisfied (4) or very satisfied (5). Likert-scales are ordinal variables that are commonly treated as continuous variables in
order to perform parametric statistical analysis. However, it is acknowledged that special caution is required when interpreting the results [25].

A phone survey is performed based on a cluster sampling technique. Sample size increases over the years from 13,000 in 2001 to above 50,000 respondents for 2010 onwards and is not limited to PT users. The total number of respondents interviewed between 2001 and 2013 is 515,044, which is about 40,000 respondents on average each year. Of which, 405,340 respondents were retained in the analysis after removing respondents that reported that they never use PT, since this study is concerned with the determinants of satisfaction with PT services. The survey includes questions concerning general satisfaction with public transport for the entire analysis period, whilst questions concerning the satisfaction with the latest trip were added to the survey only in 2011. In order to enable the analysis of temporal variations, only general satisfaction is considered in this study.

In order to correct for any potential geographical distortion between the survey sample and the population, proportional weights were assigned based on the year-specific ratios between both the county and urban area size in the survey vs. the population. Although the representation of most counties corresponds reasonably well to their respective share of the population, some counties such as the three metropolitan areas are underrepresented for most of the years while others are overrepresented. This is especially relevant in the case of Sweden, a country that encompasses sub-arctic to continental climates with highly independent local governance. Urban areas (In Swedish: Tätort) were also controlled for because PT services and related perceptions vary not only between PT authorities but also as function of the urban agglomeration [6].

A series of statistical analysis was performed in this study. First, a descriptive analysis of survey results in order to detect the main trends in passengers’ satisfaction and their evolution. Second, bivariate analyses of overall satisfaction as well as correlations between variables. A factor analysis is performed to group the QoSA into coherent clusters. Third, multivariate regression analysis of overall satisfaction as a function of individual attributes, trip attributes, satisfaction with various aspects. Fourth, based on the importance of each service aspect and the respective level of satisfaction, priority maps were constructed. A temporal analysis facilitates not only benchmarking between service providers but also the consideration of their trajectories. The statistical analyses were performed using Microsoft Excel and SPSS 22.0 and a tailored script written in Matlab.

4. ANALYSIS AND RESULTS

4.1 Descriptive Analysis

The distribution of key socio-demographic characteristics and mobility patterns of the weighted survey sample are presented in Figure 1. An inspection of the summary statistics indicates that the sample composition is relatively stable over time. It is evident that the sample represents diverse age and occupational groups dominated by workers (63%), followed by retired or permanent sick leave (18%) and students (13%). 7 out of 10 respondents live in a county that is at least twice more populated than the Swedish average (21.5 inhab/sq km). Notwithstanding, more than half of the respondents live in urban areas smaller than 50,000 and 27% in one of the three largest urban agglomerations - Stockholm, Göteborg and Malmö. The commuting distance constantly increased over time while the most common distance remained between 10 to 30 km. Interestingly, segmenting commuting distance by urban area size reveals that respondents living in either one of the three metropolitan areas or small urban areas (<50K), travel farther away than their counterparts.
Approximately a quarter of the respondents (27%) can be considered PT captives with no access to car and driving license and 3% reported a travel-related disability.

Even among our sample of PT users, the vast majority of respondents (82%) travel by car at least once a week. In contrast, only 42% of them travel at least once a week by PT. Hence, the sample consists on regular, occasional and those who use PT very seldom. The frequency of PT usage is highest in the three metropolitan areas and decreases with both the population size of both county and urban area. The reverse trend is observed for car usage. As could be expected, urban and regional PT are the most commonly used PT modes for 85% of the respondents with more than half attributed to city buses.

![FIGURE 1 Socio-demographic and mobility profile of the survey sample](image)

The evolution of satisfaction with PT and each of the QoSA was investigated. Figure 2 presents the average satisfaction reported for the 12 QoSA that were included in the survey throughout the entire analysis period, 2001-2013. Moreover, the average over these values as well as the overall satisfaction is also displayed. The following observations are made:

(a) Average overall satisfaction - hovers between 3.48-3.67 between 2001 and 2013. The general trend is of increasing overall satisfaction between 2001 and 2006 followed first by a minor decrease and then a more noticeable decrease from 2010 to 2012. It should be noted that according to the Swedish Meteorological Institute the 2010-2011 winters were exceptionally cold and long in Sweden, presumably resulting with a large number of PT service disruptions across the country.

(b) Most satisfied over time - passengers are consistently more satisfied with 6 of the 12 QoSA with a remarkable improvement in the satisfaction with General Information and deterioration in the satisfaction with Ticket Accessibility during the analysis period. The former is plausibly due to the deployment of stop and on-board displays while the latter is attributed to the non-smooth introduction of smart card and SMS tickets across Sweden and the removal of on-board ticket sale. Other high performers include ambient factors such as Freedom from Crime, Ride comfort and On-board conditions. In contrast, passengers are less satisfied with system functional attributes such as Network and Operation.
(c) Least satisfied over time - at the lower end of the spectrum, passengers are consistently dissatisfied (average score below 3) with Customer interface and Information on unplanned changes. As could be expected, the satisfaction with information is highest for pre-trip information (General information) and lowest for information about unplanned changes, whilst information concerning planned changes in between. However, it is remarkable that the information attributes are the best and worst performs from 2007 onwards. Customer interface and Information on unplanned changes stand out as the worst performers which had a clear improving trend in 2001-2006 but have since decreased back to their original levels.

A further investigation into the relation between overall satisfaction and individual attributes suggests that passengers with longer commuting distances tend to be less satisfied while more frequent users and pensioners are on average more satisfied. Passengers who use city bus, tram or metro as the most common PT mode reported the highest satisfaction level. Interestingly, the simple average of all 12 QoSA follows very closely the average overall satisfaction. This may suggest that all QoSA weights equally in determining satisfaction. However, this aggregate trend observation may not hold true at the disaggregate level or may disguise more complicated relations. The following section will examine the correlations between various factors followed by the estimation of several models based on the disaggregate combination of individual and satisfaction variables.

4.2 Cross-Correlations
A cross-correlation matrix was computed in order to identify the individual attributes and travel habits that are most strongly correlated to satisfaction with individual QoSA and overall satisfaction (Figure 3a) as well as the correlations between satisfaction scores (Figure 3b). Categorical variables (occupational group and the most used PT mode) are omitted from this
The cross-correlation matrixes are presented as a graph, where each variable - individual attributes in the inner ring and satisfaction on the outer ring - is represented as a node and the correlation between each pair of elements is represented as a link connecting the respective nodes. Link thickness is proportional to the degree of correlation - the thicker the line the larger the correlation. The cross-correlation graphs were plotted using the Excel add-on NodeXL and the *Harel-Koren Fast Multiscale* (Figure 3a) and the Circle (Figure 3b) algorithms, offering an intuitive glimpse of variable relations.

As clearly visible in Figure 3(a), none of the individual attributes in the inner-circle is strongly correlated with overall satisfaction. This result will also be paramount in the model estimation results presented in the next section. Solid blue lines depict a positive Pearson correlation coefficient above 0.2 while dashed red lines represent negatively correlated items. Accordingly, frequency of travel by PT is positively correlated with satisfaction with network and operations. The exact opposite trend is observed for frequency of traveling by car. This could be attributed to either knowledge advantage or a cognitive dissonance. The satisfaction with on-board conditions is negatively correlated with the population density of the county and positively correlated with urban area size. Those living in larger urban areas also tend to be less satisfied with operations, presumably due to the greater uncertainty associated with large and congested PT systems.
FIGURE 3 (A) Cross-correlations among individual attributes (inner-ring) and satisfaction (outer-ring); (B) Cross-correlations among QoSA and overall satisfaction

Clustering QoSA with Factor Analysis

Overall satisfaction is positively correlated with all of the QoSA where the Pearson correlation coefficient is 0.3 or higher (Figure 3b). A particularly high correlation is observed for Length of trip time followed by Customer interface, Freedom from crime, Operations, Network and Travel information concerning planned and unplanned changes. The correlations between satisfaction indicators with various QoSA are all positive. In other words, a passenger that is satisfied with a particular service aspect is more likely to be satisfied with all other aspects. This might be attributed to the bias induced by the well-known halo effect. However, this tendency varies considerably for different pairs of QoSA. Particularly strong links were found for Network and Operations as well as between information on planned and unplanned changes.
The correlations among QoSA suggest that they could potentially be clustered into distinctive factors which embrace a set of strongly related attributes as is also visible in Figure 3(b). This was examined by performing a factor analysis using the principal component analysis as the extraction method. Applying this method to our dataset yielded 3 components with the following composition (the respective coefficients of the structure matrix are given in brackets):

- **Soft** – On-board conditions (0.772), Ride comfort (0.764), Staff and assistance (0.750) and Freedom from Crime (0.731)
- **Functional** – Network (0.866), Operation (0.851) and Length of trip time (0.652)
- **Information** – Travel information changes schedule and route (0.822), Travel information delays and stops (0.814), Customer interface (0.690) and General information (0.592)

The factor analysis groups 11 out of the 12 QoSA (Ticket accessibility was removed because it was inconsistently grouped when testing it for different years) into meaningful and coherent clusters. The component correlation matrix indicates that Oblimin Rotation should be employed where the Soft and Functional factor having the lowest correlation while Information equally varies jointly with both factors. The component solution explains a total of 60% of the variance, with Soft component contributing a 39% and Functional and Information components explaining 12% and 9%, respectively.

### 4.3 Service Satisfaction Models

A large number of ordered logit regression models were specified and estimated in order to systematically investigate the determinants of overall satisfaction. In order to study whether the determinants changes over time, alternative models were estimated separately for each year as well as for the whole dataset. Individual attributes, satisfaction with QoSA and the factors identified in the previous section were tested as potential explanatory variables. Multicollinearity indicators (bivariate indicator, tolerance and variance inflation factor) were computed and all their values suggested that none of the independent variables exercise multicollinearity issues. The selection of model specification was based on a hierarchical estimation approach while observing that estimated values are stable over time.

Given the fact that overall satisfaction is an ordinal variable, ranging from 1 (very unsatisfied) to 5 (very satisfied), ordered logit models are most adequate. In general, order logit model can be expressed as:

$$ y_k^* = X_k \beta + \epsilon_k $$

Where $y_k^*$ is the latent dependent variable of individual $k$, $X_k$ is the explanatory variable set of individual $k$, which includes individual QoSA and the type of public transport user for individual $k$. Note that the intercept is dropped for identification issues. $\beta$ is the corresponding parameters to be estimated. $\epsilon_k$ is the error term which is assumed as an identically distributed logistic error-term. The latent dependent variable is then associated with the observed dependent variable, $y_k$ (5 likert scale overall satisfaction), with $m=1..5$, defined as follows:

$$ y_k = \begin{cases} 
1, & \text{if } -\infty < y_k^* < \mu_1 \\
2, & \text{if } \mu_1 < y_k^* < \mu_2 \\
\vdots \\
 m, & \text{if } \mu_{m-1} < y_k^* < +\infty 
\end{cases} $$

Note that the parameter estimates obtained from different ordered logit models cannot be directly compared. Instead, the marginal effects on the expected value of the dependent variable (overall satisfaction) were derived from the parameter estimates. For a given
explanatory variable \( i \), the marginal effect on the probability of observing individual \( k \) having an overall satisfaction equal to \( n \) is:

\[
M_{k,i,n} = -\beta_i \left[ \frac{e^{-(\mu_n-x_k\beta)}}{1+e^{-(\mu_n-x_k\beta)}} \right] = \frac{e^{-(\mu_{n-1}-x_k\beta)}}{(1+e^{-(\mu_{n-1}-x_k\beta)})^2}
\]

(3)

The marginal effect of the explanatory variable \( i \) on the expected value \( E(y_k) \) for a given individual \( k \) is then:

\[
E_{k,i} = \sum_{n=1}^{m} M_{k,i,n} \times n
\]

(4)

This marginal effect at sample mean is then derived:

\[
E_i = \left( \sum_{k=1}^{Nobs} E_{k,i} \times weight_k \right) / \sum_{k=1}^{Nobs} weight_k
\]

(5)

Table 1 presents the results of the estimated coefficients of the order logit models and the respective Wald chi-square test value in parentheses for selected models. The marginal effects \( E_{k,i} \) are also presented. In the case of yearly QoSA models, the range of estimated values obtained for the independent estimation of year-specific models is shown. All the QoSA included in the models are significant at the 95% level and most of them at the 99% level. None of the socio-demographic variables (e.g. gender, age, occupation) was consistently significant. Among travel habit variables (e.g. car availability, commuting distance), only the frequency of travelling by PT was systematically significant. This is overall in line with the results of the cross-correlation analysis. Furthermore, combinations of moderator variables based on previous results in travel behavior theory were tested (e.g. influence of comfort for trips longer than 50km, freedom from crime and women) but none of them improved the explanatory power of the model. Frequency of travel by PT was defined as a dummy variable with respondents that travel less than once a month as the base case. The results indicate that regular travelers are more satisfied than irregular travelers even after controlling for their satisfaction with specific QoSA.

Each model in Table 1 either includes the three factors or the individual QoSA. The first model includes the three factors as explanatory variables and is estimated jointly for the entire dataset from 2001-2013. The Soft and Functional factors have a similar impact on the overall satisfaction followed by the Information factor. The second model also refers to the entire dataset but is based on the individual QoSA. While this model is more complicated as it includes a larger number of variables, it enables to investigate the contribution of each individual QoSA to the overall satisfaction.

Satisfaction with Customer interface, Length of trip time, Operation and Freedom from crime were found to have the largest impact on the overall satisfaction. These QoSA were found consistently important throughout the entire analysis period based on the results of year-specific models (last column in Table 1). The estimated coefficient of some QoSA varies considerably for different years exceeding a 100% difference in the case of On-board conditions, Ticket accessibility, Information on unplanned changes and General information. A statistical comparison of the change in estimated values between 2001 and 2013 indicates that the importance of On-board conditions, Information on unplanned changes and General information has significantly increased while the impact of Freedom from crime, Operation and Length of trip time on overall satisfaction has significantly decreased over the study period.
### TABLE 1 Service Satisfaction Models

<table>
<thead>
<tr>
<th>Models</th>
<th>Joint factors model</th>
<th>Joint QoSA model</th>
<th>Yearly QoSA models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
<td>Coeff. (Wald)</td>
<td>Coeff. (Wald)</td>
<td>Coeff. [range of values] (≤ Wald ≤)</td>
</tr>
<tr>
<td>Intercept</td>
<td>0 (fixed)</td>
<td>0 (fixed)</td>
<td>0 (fixed)</td>
</tr>
<tr>
<td>Ticket accessibility</td>
<td>0.131 (838.8)</td>
<td></td>
<td>[0.069, 0.176] (8.7, 182.3)</td>
</tr>
<tr>
<td>Soft factor</td>
<td>0.992 (31299.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ride Comfort</td>
<td>0.101 (282.8)</td>
<td></td>
<td>[0.066, 0.216] (6.9, 88.1)</td>
</tr>
<tr>
<td>On-board conditions</td>
<td>0.157 (739.6)</td>
<td></td>
<td>[0.069, 0.286] (15.4, 101.6)</td>
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<tr>
<td>Staff and assistance</td>
<td>0.297 (2498.9)</td>
<td></td>
<td>[0.240, 0.363] (58.1, 371.8)</td>
</tr>
<tr>
<td>Freedom from crime</td>
<td>0.465 (5194.2)</td>
<td></td>
<td>[0.281, 0.545] (50.6, 592.9)</td>
</tr>
<tr>
<td>Functional factor</td>
<td>0.968 (25310.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network</td>
<td>0.240 (2428.2)</td>
<td></td>
<td>[0.201, 0.291] (45.2, 337.2)</td>
</tr>
<tr>
<td>Operation</td>
<td>0.355 (5629.7)</td>
<td></td>
<td>[0.275, 0.434] (99.6, 843.8)</td>
</tr>
<tr>
<td>Length of Trip time</td>
<td>0.521 (7401.1)</td>
<td></td>
<td>[0.438, 0.575] (188.1, 1003.4)</td>
</tr>
<tr>
<td>Information factor</td>
<td>0.860 (21498.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Info. on planned changes</td>
<td>0.174 (1034.7)</td>
<td></td>
<td>[0.122, 0.189] (31.2, 131.3)</td>
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<tr>
<td>Info. on unplanned changes</td>
<td>0.186 (1215.4)</td>
<td></td>
<td>[0.111, 0.239] (25.5, 182.8)</td>
</tr>
<tr>
<td>Customer interface</td>
<td>0.521 (8480.7)</td>
<td></td>
<td>[0.439, 0.605] (198.2, 1084.1)</td>
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<td>General info.</td>
<td>0.129 (726.3)</td>
<td></td>
<td>[0.054, 0.286] (8.9, 174.9)</td>
</tr>
<tr>
<td>Daily PT user</td>
<td>0.070 (24.9)</td>
<td>0.128 (81.9)</td>
<td>[-0.023, 0.491] (0.1, 31.8)</td>
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<tr>
<td>Weekly PT user</td>
<td>0.155 (138.7)</td>
<td>0.192 (209.1)</td>
<td>[0.023, 0.345] (0.3, 54.6)</td>
</tr>
<tr>
<td>Monthly PT user</td>
<td>0.085 (41.7)</td>
<td>0.104 (62.4)</td>
<td>[0.05, 0.256] (0.3, 30.7)</td>
</tr>
<tr>
<td>Threshold $\mu_1$</td>
<td>-5.982 (74954.5)</td>
<td>5.365 (25454.2)</td>
<td>[4.783, 6.214] (681.1, 3063.9)</td>
</tr>
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<td>------------------</td>
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</tr>
<tr>
<td>Threshold $\mu_2$</td>
<td>-3.650 (70711.9)</td>
<td>7.743 (54123.8)</td>
<td>[7.193, 8.812] (1317.9, 6231.5)</td>
</tr>
<tr>
<td>Threshold $\mu_3$</td>
<td>-0.528 (2745.8)</td>
<td>10.919 (83799.9)</td>
<td>[10.261, 12.118] (2067.7, 9579.7)</td>
</tr>
<tr>
<td>Threshold $\mu_4$</td>
<td>3.419 (66010.4)</td>
<td>14.927 (109638.8)</td>
<td>[14.152, 16.190] (2603.1263)</td>
</tr>
<tr>
<td>Log-likelihood at zero</td>
<td>-245688.71</td>
<td>-245688.70</td>
<td>[-30276.38, &lt; -6182.19]</td>
</tr>
<tr>
<td>Log-likelihood at final</td>
<td>-171001.80</td>
<td>-168560.23</td>
<td>[-20949.65, -4363.79]</td>
</tr>
<tr>
<td>McFadden</td>
<td>0.303</td>
<td>0.293</td>
<td>[0.284, 0.327]</td>
</tr>
<tr>
<td>No. of observations (N)</td>
<td>207692</td>
<td>194804</td>
<td>[4975, 23844]</td>
</tr>
</tbody>
</table>

Each cell contains the estimated coefficient value followed by the Wald coefficient in parentheses. In the case of the yearly QoSA models, the range of values obtained is reported.

### 4.4 Identifying Priority Service Areas

Monitoring trends in passengers’ priorities and satisfaction is of imperative importance to transport agencies and operators. Such an analysis is facilitated by combining the results of the reported QoSA and the respective coefficients obtained from the year-specific QoS models. Figure 4 presents passengers’ priority map where the x-axis corresponds to the estimated coefficient value and the y-axis corresponds to the average satisfaction normalized based on the average satisfaction across all QoSA as proposed by Trompet et al. [8]. The average values are used for determining the x and y pivots of the coordinate system. The horizontal dashed line corresponds to the intermediate satisfaction score of 3. Each year-specific combination of satisfaction and importance is depicted with a number from 1 to 13 corresponding to year 2001 to 2013. Each variable is presented with a different color to allow a direct interpretation of the map at first glance. In summary, the dynamic priority map involves the assessment of satisfaction against the average over the analysis period, a baseline as well as a trend analysis.
FIGURE 4 Passenger satisfaction priority map

The priority map results with four areas:
(1) **Prioritize**: high importance-low satisfaction (top right quadrant);
(2) **Preserve**: high importance-high satisfaction (bottom right);
(3) **Consider**: low importance – high satisfaction (bottom left), and;
(4) **Improve**: low importance-low satisfaction (top left).

It is evident that the relative satisfaction with most QoSA is fairly stable throughout the analysis period. In contrast, the relative importance associated with QoSA changes for a large number of service aspects. We observe that for a given variable most of the changes are horizontal rather than vertical. This is most noticeably the case for Length of trip time, Freedom from crime, Customer interface, Information on unplanned changes, Operation and On-board Conditions. The relative satisfaction and importance attached to two QoSA – General information and Ticket accessibility – have changed considerably. In the case of General information the satisfaction increased simultaneously as the importance decreased, most notably between 2006 and 2007. In contrast, satisfaction with Ticket accessibility gradually decreased between 2001 and 2013 while the importance first decreased and then rebounded. Insignificant changes in both dimensions are observed for Network, Staff and assistance and Information on planned changes.

In the case of PT in Sweden, Customer interface stands out as the most important priority area that passengers are constantly dissatisfied with in both absolute and relative terms while being one of the most important determinants of overall satisfaction. Operation followed by Length of travel time are other areas of priority– these three QoSA constitute the Functional factor. Length of travel time is also gaining greater importance over time while maintaining an average relative satisfaction. There are two QoSA in the second quadrant; Freedom from crime where the operator should maintain the good job, and Staff and Assistance. Passengers are also very satisfied with the less importance QoSA of General
Information, Ride Comfort, On-board conditions and Accessibility ticket, although the latter two gradually slide in the direction of the fourth quadrant. Travel information on planned and unplanned changes is an area for improvement but with lower priority.

5. CONCLUSION

Using a time-series data from Swedish Public Transport Barometer that was regularly collected from 2001 to 2013, this study analysed how users’ satisfaction with PT service and its underlying determinants evolve over time. The analysis approach used in this study could be used as a market analysis tool to assess PT priority area. Moreover, the analysis of the trajectories of different PT systems or their sub-divisions (by city or mode) can provide insights on whether policy measures lead to improved satisfaction with QoSA.

Overall satisfaction with PT in Sweden follows a negative trend in recent years (2010-2013) driven by a decrease in users’ satisfaction with most QoSA and in particular a decrease in satisfaction with Customer interface and Length of trip time which are among the most important determinants of overall satisfaction. Moreover, Customer interface, Operation and to a lesser extent also Length of trip time, were found key determinants of overall satisfaction which users consistently rate among the least satisfactory. Therefore these service aspects should be prioritized by transit agencies and operators in Sweden. This implies taking measures to identify and improve areas of poor service accessibility and reliability or where PT became less attractive compared with private car such as employment and shopping centres on the urban fringe. In contrast, the deterioration of satisfaction with customer interface is related to the reputation of the PT agency and could be addressed by improving both internal (mechanisms to handle passengers’ complaints) and external communication (media, marketing).

Maintaining a sense of security is also crucial as it is an important determinant of overall satisfaction and an area that PT users in Sweden are generally satisfied with although also showing a slight negative trend since 2010. Other areas of dissatisfaction although with lower importance include Information on planned and unplanned changes as well as the sloping satisfaction with Ticket accessibility. It should be noted that these service aspects attracted considerable media attention in recent years. In line with the results reported by previous studies [e.g. 31] passengers with longer commuting distances tend to be less satisfied while more frequent users and pensioners are on average more satisfied. The results of this study are therefore instrumental in supporting regional PT providers and authorities such as county councils and municipalities in providing a service that better suits their communities needs and design investments that will foster satisfaction in the future.

This study is enabled by a time-series dataset. The systematic and regular collection of information concerning satisfaction with PT service is becoming an industry standard. It is important to maintain a consistent set of questions to facilitate the analysis of long-term trends. The analysis of seasonal variations could also shed light on the impact of changes in demand levels and climate on travel satisfaction. Furthermore, an analysis of a panel data could facilitate the analysis of whether the overall change in QoSA is driven by a systematic change in individual perceptions. For example, whether greater importance is attached to a QoSA that an individual is less satisfied with or variations among PT user groups, as well as non-users [32-33].

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