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Revisiting public transport service delivery: exploring rail commuters' attitudes towards fare collection and verification systems

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Making Public Transport services more attractive and effective requires attractive and effective ticketing. This requires a clear understanding of user attitudes, needs and expectations. This study explored commuters' attitudes to fare collection and verification and the underlying factors, their acceptance of the policy of "No-ticket-purchase on-board" and their preferences for fare verification options. Commuters rated their agreement with 17 ticketing related statements in a cross-sectional questionnaire survey conducted along the corridor with the largest proportion of cross-county commuting in Sweden, Stockholm – Uppsala. Four sets of hypotheses were then tested. The average scores were normally distributed and hence analysed using a two-way ANOVA. A One-way chi-square test was conducted to determine the commuters' preference for fare verification approach. A t-test was used to analyse the perceived quality of ticketing and the commuters' reaction to the policy of "No-ticket-purchase on-board PT vehicle". Whilst the results showed that the commuters were relatively uniform in their attitudes, income, commuting route, ticket type and ticket purchase channel affected their attitudes. They were neutral to the policy of "No-ticket-purchase on-board". Their attitude to fare collection was more positive than that of fare verification and they showed a preference for automatic fare verification. The study highlights a number of policy implications and recommends further research on the feasibility of passive fare verification and on commuters' preferred options for fare verification.

Keywords*: Attitudes, commuters, convenience, fare collection, fare verification, ticketing.*

1. Introduction

The fare is one of the main service aspects of public transport (PT) that enables service providers and stakeholders to achieve ridership targets (Paulley et al., 2006, Redman et al, 2013). Fare

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policies are generally implemented by means of ticketing, and this constitutes the interface between a PT user and the PT service. Hence, ticketing is an integral part of the PT system and one of the aspects of the PT service that affects user convenience and accessibility and, consequently, PT service quality (SQ).

PT ticketing requires the active participation of users. That is, users are required to allocate some time and effort to the processes of PT fare collection and fare verification. Users need to allocate time and effort, firstly, into the act of paying for a trip - fare collection, and secondly, into enabling the service provider to check that passengers have paid for the intended or completed journey - fare verification (BRT Planning Guide, 2007). Given that PT ticketing is not an end by itself but a means of accessing the PT service, it constitutes a source of inconvenience to users compared to, for instance, users of the private automobile. Yet, little is known about users' attitudes and perceptions towards these two main dimensions of ticketing.

Using Stockholm – Uppsala corridor in Sweden as a case study, this study contributes to the literature by exploring commuters' attitudes to fare collection and verification systems and the underlying factors, their perceived quality of these systems, their acceptance of the policy of "No-ticket-purchase on-board" as well as their preferences for fare verification options. Four research questions are addressed by the study:

What factors influence PT commuters' attitudes to PT ticketing? (I.e. are there any differences between the average attitudinal scores of the different commuter segments?).

What are PT commuters' attitudes towards PT fare collection and verification systems?

Do PT commuters have preferences between the available fare verification options?

Does familiarity with the policy of "No-ticket-purchase on-board PT vehicle" breed its acceptance amongst PT commuters?

Consequently, four sets of hypotheses were tested to address these questions. Given that all the independent variables were categorical and that the dependent variable (average scores) was normally distributed, a two-way Analysis of Variance (ANOVA) was used to analyse heterogeneity in the mean attitudinal scores. A One-way chi-square test was conducted to determine the commuters' preference for fare verification approach and a t-test was used to analyse their perceived quality of ticketing and their reaction to the policy of "No ticket purchase on-board PT vehicle".

The four main contributions of the study are:

1. It provides insight into the factors that affect commuters' evaluation of the quality of fare collection and verification;
2. It proposes a future direction for improving PT fare verification. Thus, by identifying the commuters' preferred choice of fare verification, Public Transport Authorities (PTA's) could use the results to support decisions on future fare verification systems.
3. It provides rail service providers along the Stockholm-Uppsala corridor with information on the acceptance of the policy of "No-ticket-purchase on-board PT vehicle" by users. Other PTA's who intend to implement this kind of policy may draw on this example.
4. It provides the service providers within the study area with up-to-date information on the quality status of fare collection and verification, thus providing some base data for evaluating the perceived quality of fare collection and verification both before and after the implementation of the Movingo integrated season ticket project. Movingo which is described in section 3 is an integrated ticketing scheme among six neighbouring PTA's and a commercial rail service provider (the Swedish national railways, SJ).

The rest of the paper is organised as follows. The next section provides a review of literature on PT SQ studies and ticketing. Section 3 describes the study area. Section 4 presents the theoretical framework, attitude measurements and how the data was collected and analysed. Section 5 focuses on the findings. Section 6 offers a discussion of the results and the final section provides some concluding remarks.

2. Literature review

PT SQ measurements is of high importance for both PT service providers and regulatory agencies as this is central to retaining current users and attracting new users. This motivates many studies on PT service quality and satisfaction using data often collected from user surveys (De Oña and De Oña, 2014). Two main perspectives on the measurement of service quality and user satisfaction exist. Based on user experience (perceived quality) or based on users' expectation (expected quality). The former is more common in PT service quality studies (Allen et al, 2018). Perceived quality is commonly measured as an attitude in PT SQ studies (De Oña and De Oña, 2014). Perception refers to how something is viewed, understood or interpreted. An attitude, on the other hand, refers to the value an individual put on something (often known as the attitude object) and it may be negative, neutral or positive (Richardson, 2014).

A fundamental feature of PT SQ studies is that the overall perceived quality of a given PT system is measured by including relevant factors from different aspects of the PT service as experienced and reported by users. Identifying these relevant set of quality dimensions poses a challenge (Hensher et al., 2003) as no general standard currently exists. Many attributes have been proposed in different studies in efforts to correctly define PT service quality. Redman et al. (2013) grouped them into two. The first group attributes such as reliability, speed, travel time, etc. are those that can objectively or physically be measured without involving users. The second group are those perceived attributes such as comfort, convenience, ease of use, etc., which are measured by involving users through for instance user surveys. The quality dimensions commonly used in measuring PT service quality are presented in Table 1.

PT ticketing is a tool for implementing a PT fare policy and thus, an integral part of the PT system. Whilst its main aim is to collect revenue, it has been confirmed to be characterized by factors that affect passenger convenience and comfort, passenger information requirements, accessibility, vehicle dwell times (which affects travel time and service frequency), service reliability, passenger security, operator security, complexity of PT infrastructure and hence aesthetics, PT revenue collection cost and consequently PT demand (Puhe, 2014; White, 2009; and Vuchic, 2005). Thus, it remains an important aspect of PT SQ and operational efficiency (Blythe, 2004). Consequently, making PT services more attractive and effective requires attractive ticketing and this is only possible through a clear understanding of user attitudes, behaviour, needs and expectations (Anderson et al., 2013, Schiefelbusch, 2009).

Masabi (2016) reported customer satisfaction as one of the major benefits of mobile ticketing as users no longer need to wait in ticket lines. Similar benefits have been reported from implemented smart card technologies such as the Oyster in London, SL Access card in Stockholm, Combi-card in Tampare, Octopus in Hon Kong, Charlie card in Boston, Te´ce´ly card in Lyon, Myki card in Melboune, PASMO and Suica card in Tokyo (UK department for transport, 2009; Blythe, 2004). Obviously, the evolution from paper tickets and tokens to magnetic strips, smart cards and mobile devices as well as the volume of ongoing ticketing improvement interventions and investments globally confirms the magnitude of PT ticketing problems that service providers and other stakeholders are seeking to minimize or eliminate. For instance, making fare collection more convenient for users is a major recommendation in Northeast Florida's regional fare study (2018). The UK department for transport (2009) in its smart and integrated ticketing strategy also emphasised that ticketing should focus on the passenger.

Transport for London having succeeded with the Oyster card has set out a vision for improved and integrated electronic transport ticketing infrastructure for the whole of England by 2020 (Turner and Wilson, 2010). In Mass Transit survey (2016), over two hundred PT professionals were interviewed and most of them (at least 66%) agreed that fare evasion, cash handling and customer satisfaction are the three top challenges that new ticketing technologies need to solve. The survey cited available ticketing options, convenience of purchase, speed of purchase, and simplified fares as the ticketing attributes that need enhancement.

Yet, the assessment of the quality of PT ticketing systems and attitudes to ticketing have received limited consideration in published PT literature. As summarised in Table 1, even though PT SQ and satisfaction studies is a matured field of study, previous studies have tended to exclude the perceived quality of PT ticketing as a quality dimension of the PT service. PT user inconveniences such as ease of purchase, speed of purchase, barrier effects of turnstiles, ease of use of ticket vending machines, accessibility to tickets and inter-transit systems transfer challenges are some obvious issues associated with ticketing. While these issues may relate to fare, and fare is clearly a very important determinant of PT demand, the effects of perceived quality of PT ticketing on user experience are not the same as that of fare. Many of the studies that included fare in the evaluation of the perceived service quality of PT systems overlooked ticketing aspects (Mahmoud and Hine, 2016; De Oña and De Oña, 2015; De Oña et al., 2013; Eboli and Mazzulla, 2010). Very few studies included some aspects of ticketing inconveniences as a relevant factor in PT SQ evaluation, and these were often limited to aspects of fare collection, with almost no consideration of fare verification aspects. For instance, Carreira et al (2013) included only ticket line service, measured as empathy at the ticket line and not having to wait to buy a ticket. Also, Abenoza et al. (2016) included ease of purchasing tickets as an attribute in their analysis of travel satisfaction with PT in Sweden from 2001 to 2014 and reported that it generally followed a negative trend.

While the holistic analysis of PT service quality is undeniably valuable for improving its ability to compete favourably with alternative travel modes, looking into specific aspects of PT service quality provides in-depth understanding of how current PT users perceive these aspects. For instance, many studies have been conducted on users' perceptions of specific PT service aspects such as fares (Balcombe et al, 2004); travel time (Wardman, 2014); overcrowding (Batarce et al, 2016); free transfer (Chowdhury and Ceder, 2016); bus stop and station attributes; vehicle attributes; travel information; delay; rail service attributes (Douglas and Karpouzis, 2006) etc. Yet, little is known about attitudes and perceptions of PT users towards PT ticketing and its integration factors (Chowdhury and Ceder, 2016). Consequently, given the importance that attitudes and perceived quality play in understanding and improving PT systems, it is important that users' attitudes towards PT ticketing and their perceived quality of ticketing systems are explored.

Commuters are an important and well-defined group of users, and commuting constitutes a substantial portion of daily trips globally (SKL, 2008; Beck and Hess, 2016). Furthermore, where commuting involves crossing municipal boundaries or national borders there is the potential for PT ticketing issues to be heightened. In Sweden, 31% of the working population commuted beyond municipal boundaries in 2006 and the total number of commuters between Sweden and it's three neighbouring countries as at 2005 was 31865 (SKL, 2008).

The objectives of this paper are thus twofold. To investigate commuters' attitudes towards PT fare collection and fare verification systems, and their perceived quality of these systems using the corridor with the largest proportion of cross-county commuting in Sweden, Stockholm – Uppsala, as a case study.

3. Description of the case study area and the Movingo project

With increased PT usage from about 18% to 27% between 2006 and 2014 (Association of the Swedish Public Transport, SKT, 2016), Sweden is one of the seven countries in the European Union where the growth of PT usage has been sustained between 2010 and 2014 (UITP, 2016). This trend is expected to continue and, as efforts are made towards achieving the national goal of doubling PT usage and in line with the EU Interoperable Fare Management Project (EU IFM), more PT ticketing improvement schemes are being implemented in Sweden than ever before. Movingo is one such ticketing improvement initiative among six neighbouring Public Transport Authorities (PTAs) and a commercial rail service provider (the Swedish national railways, SJ). It is a smartcard and mobile phone based multi-operator season ticket that applies to both intercity and intracity bus and train services within and across the geographic boundaries of the cooperating six counties, called the Mälardalen region (Figure 1).

With the Movingo ticket, commuters have the option to buy a season ticket that is valid for at least two of the counties. Sales of Movingo started in October 2017 with commuters and other frequent travellers as the target group. It has options for only one month, three months and one year but no options for periods less than 30 days. With an average monthly sale of 13400, a total of 53700 Movingo tickets were sold within the first four months of Movingo (Figure 2). The Stockholm – Uppsala route section has the largest share, and 90% of the tickets sold were 30 days tickets. Tickets bought are non-refundable and season tickets for periods less than 30 days are still available from the individual service providers.

The main smart aspects of Movingo are: seamless transfers across different PT modes within the entire region, improved convenience for users (as they no longer need to hold more than one season ticket), simplified fare and zone structure, improved ease of commuting by PT, flexibility to buy the ticket anytime and anywhere, time savings through reduced queues at ticket sale's points, discounts for students, reduced transaction and administration costs, reduced fraud and enhanced data acquisition.

The Stockholm – Uppsala corridor (marked by the red ring line in Figure 1), which has the largest proportion of cross-county commuting trips in Sweden, was the area of focus for this investigation. Both PTAs in the study area use a hybrid fare structure that combines both flat fare and zonal graduated fare structures. The flat fare applies to season tickets while the zonal graduated fare applies to single-journey tickets. The Swedish national railways, SJ, however has a distanced-based fare structure, largely between intercity train stations. The pricing strategy for Movingo is thus both flat and distance-based.

Figure 3 presents the demand growth for Movingo within the first one year of its implementation. There was 1.2% increase in sales in October 2018 compared to October 2017 (the launch month). Demand is lower in December and lowest in July since these are normally holiday months.

4. Methods

4.1 Theoretical framework

The concept of service quality (SQ) and Attitudes
Parasuraman et al. (1985) defines SQ as the difference between customer expectation and her perception of service performance. Even though the SQ concept is useful for understanding how customers evaluate services, three properties of service make it a hard concept to understand and measure - intangibility, heterogeneity and inseparability. Cronin and Taylor (1992) argued that perceived service quality is best conceptualized as an attitude.

Parkany et al (2005), in their review of theory and experimentation relating attitudes to behaviour, concluded that attitudes are very important and quite prevalent in transportation studies. A representative list of the use of attitudinal surveys in analysing PT service quality is provided by De Oña and De Oña (2014).

Five psychological properties of attitudes form the basis for using attitude measurements to evaluate rail commuters' perceived quality of PT ticketing in our analysis. These five properties are summarised by Richardson (2014) as:

- Attitude is simply an evaluation on whether the attitude object is good or bad. That is, an attitude is the value an individual put on something, often known as the attitude object, and it may be negative, neutral or positive.
- Every attitude consists of three parts. Affective (Attitudes relating to feelings and emotions, e.g. feelings about PT service quality), behaviour (attitudes relating to actual behaviour, e.g. choosing to commute by train instead of by car) and cognitive (attitudes relating to thoughts or understanding as well as speech or information).
- Attitudes play four key functions: the knowledge function helps the individual to make sense of the world (e.g. knowledge of a PT ticketing system); the utilitarian function helps to serve practical purposes and achieve goals; the ego defence function helps one to have a positive view of oneself; and the value expressive function helps to express values fundamental to who one is.
- Attitudes are measurable by correctly asking questions to establish a subject's basic attitudes on any subject. Asking many subjects many questions enable us to measure aggregate attitudes at different levels of society.
- Attitudes can be influenced by the way questions are asked and stated attitudes do not necessarily match up with how people will behave in the future or what they really think.

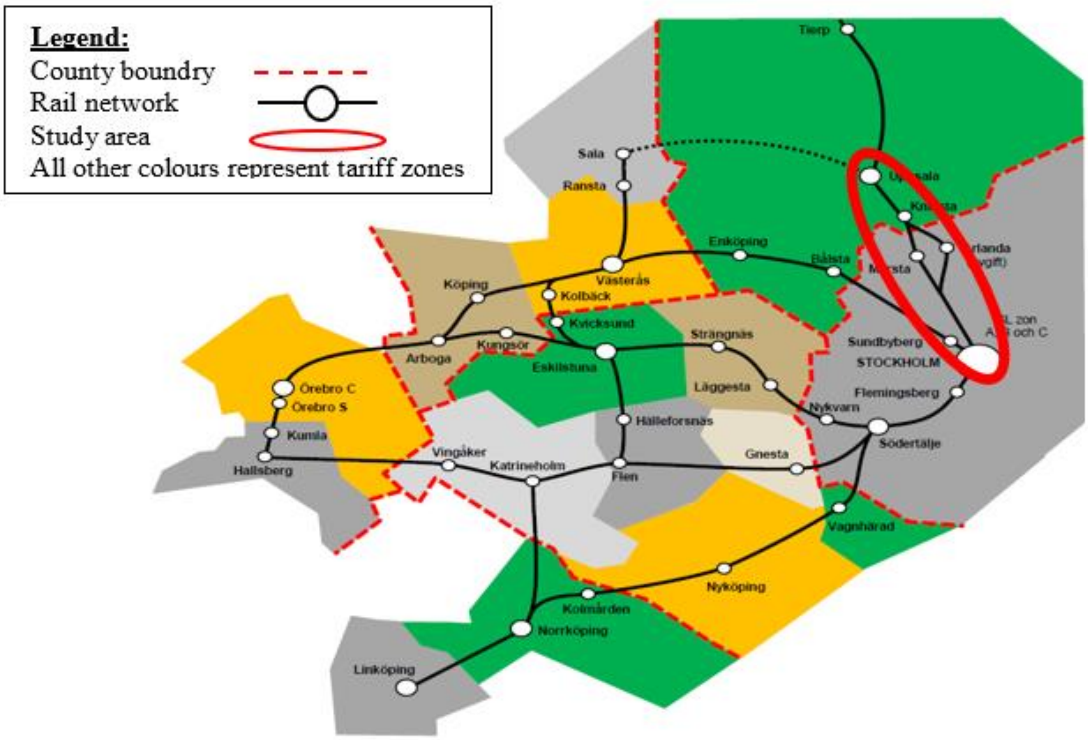

Figure 1: Tariff zones and county boundaries for the Movingo season ticket. Source: Movingo Project

Table 1. Common PT service quality dimensions. Modified from an earlier review by Morton et al (2016)

Authors	Year	Service Quality Dimensions
Jaime Allena, Juan Carlos Muñoz, Juan de Dios Ortúzar.	2018	Service frequency, bus-stop, accessibility, busses and drivers, peripheral (image)
Laura Eboli, Carmen Forciniti, Gabriella Mazzulla.	2018	Safety, cleanliness, service, facilities for disabled people (additional services), information
Mahmoud & Hine	2016	Comfort, transfer requirement, stop location, park and ride, waiting time, reliability, service frequency, information, fare, discounts and safety
Rocio de Oña & Juan de Oña	2015	Accessibility, cleanliness, courtesy, fare, service frequency, information, proximity (stops), punctuality, safety, bus space, speed and temperature
Şimşekoglu, Nordfjærn, & Rundmo,	2015	Flexibility, convenience, safety
Chou, Lu and Chang	2014	Tangibles, convenience, employee interaction and reliability
Yaya, Fortià, Canals & Marimon	2014	Functional, physical and convenience
Carreira, Patrício, Jorge & Magee	2013	Individual space, information provision, staff skill, social environment, vehicle maintenance, off-board facilities, and ticket line service
Juan de Oña, Rocío de Oña, Laura Eboli, Gabriella Mazzulla.	2013	Accessibility, cleanliness, courtesy, fare, service frequency, information, proximity (stops), punctuality, safety, bus space, speed, temperature
Susniené D.	2012	Tangibles, reliability, responsiveness, assurance, empathy
Luigi dell'Olio, Angel Ibeas, Patricia Cecin.	2011	Waiting time, vehicle occupancy, cleanliness, journey time, driver kindness, comfort
Lai & Chen	2011	Core services and physical environment
Laura Eboli, Gabriella Mazzulla.	2010	Route characteristics, service characteristics, service reliability, comfort, cleanliness, fare, information, safety and security, personnel, customer services, environmental protection.
Laura Eboli, Gabriella Mazzulla.	2010	Walking distance to bus stop, service frequency, reliability, bus stop facilities, bus crowding, cleanliness, fare, information, transit personnel
Friman & Fellesson	2009	Frequency, seat and travel time
Pérez, Abad, Carrilo & Fernández	2007	Tangibles, reliability, responsiveness, assurance, empathy
Laura Eboli, Gabriella Mazzulla.	2007	Service planning and reliability, comfort and ancillary factors, network design
Stradling, Carreno, Rye & Noble	2007	Safety, service provision, unwanted arousal, cost, disability access, self-image

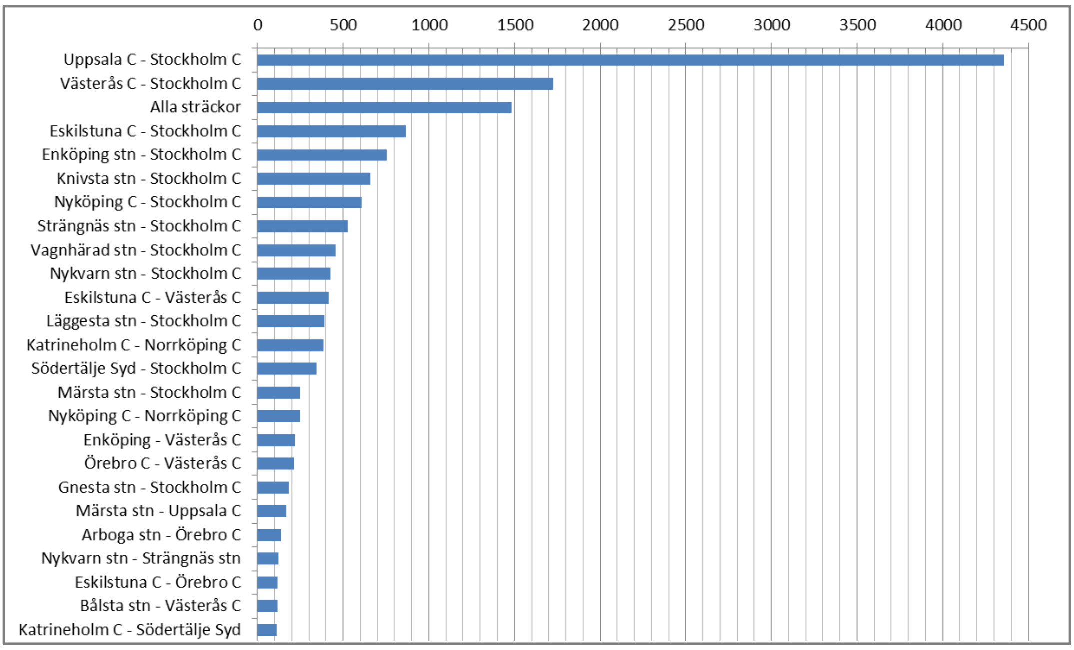

Figure 2: Average number of tickets sold per major commuting route in the first four months. Source: MÄLAB, 2018

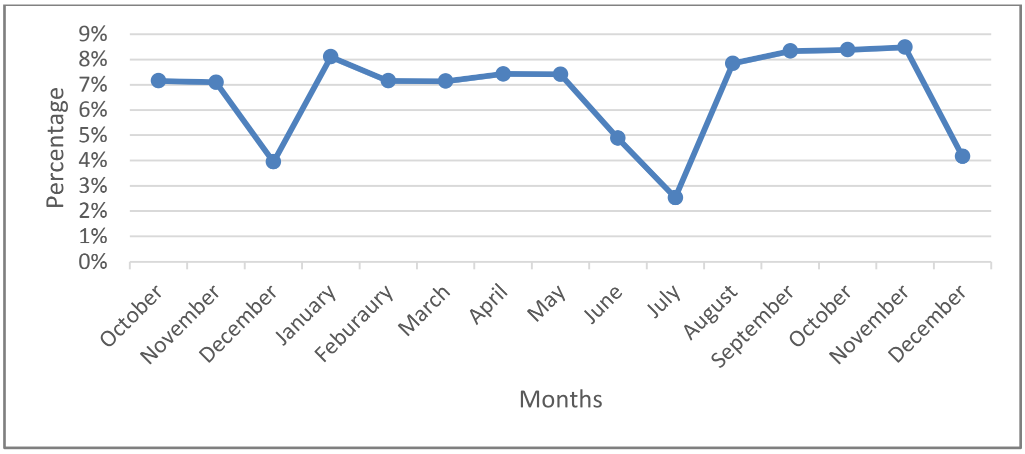

Figure 3: Monthly sale proportions of Movingo from October 2017 to December 2018. Source: MÄLAB, 2018

Conceptualising the relationship between PT ticketing quality and attitudes

The various factors that may influence the value commuters place on a given PT ticketing system are identified in Figure 4. This conceptual framework assumes that the desire by PT service providers and stakeholders to improve ticketing quality or reduce the generalised cost of PT ticketing leads to the implementation of carefully selected measures. These measures may be applied to the fare collection part, the fare verification part, the user part (behavioural measures) or fare policy (ticket types and all the principles, goals and constraints that service providers consider in setting and collecting fares) or a combination of these four elements. These interventions then cause objective effects in the ticketing system which further produces two types of effects - perceived effects for users and objective effects on PT system operational efficiency and service quality. How the perceived effects are perceived depends on the individual's travel behaviour which in turn is influenced by the individual's characteristics and preferences. Attitudes to changes in the PT ticketing system are then a function of the perceived effects for users, the objective effects on the PT system operational efficiency and the individual's travel behaviour. The feedback cycle indicates changes in system equilibrium that may be induced by any further changes in the ticketing system or individual's characteristics and preferences or both.

4.2 *Measuring the attitudes of the commuters*

Wardman (2014) identified three main approaches for measuring convenience and comfort in PT, namely: by measuring perceptions and attitudes; measuring strategic key performance indicators; or by measuring the detailed components of a generalised cost expression. While he argued that it is possible to objectively measure all convenience terms and value them by extending the generalised expression beyond time and cost, he pointed out that measuring convenience factors in ticketing are not easily measured in an objective manner and survey-based rating methods are hence required. In a literature review of quality of service in PT based on user surveys by De Oña and De Oña (2014), 92% of studies were based on survey rating and mostly Likert scale. The origin and description of this psychometric ordinal response scale can be found in Likert (1932). This method makes it easy to use a series of statements to measure commuters' feelings about the latent variable ticketing. An important feature of the Likert scale is that it is unidimensional. That is, its concepts are expressed in a single dimension that is easy to understand. For instance, a person is tall or short in height, fast or slow in walking. The scale is often expressed in the form of a statement with categories of discrete choices, normally ranging from strongly disagree to strongly agree. For each statement, the choice set is exhaustive and mutually exclusive.

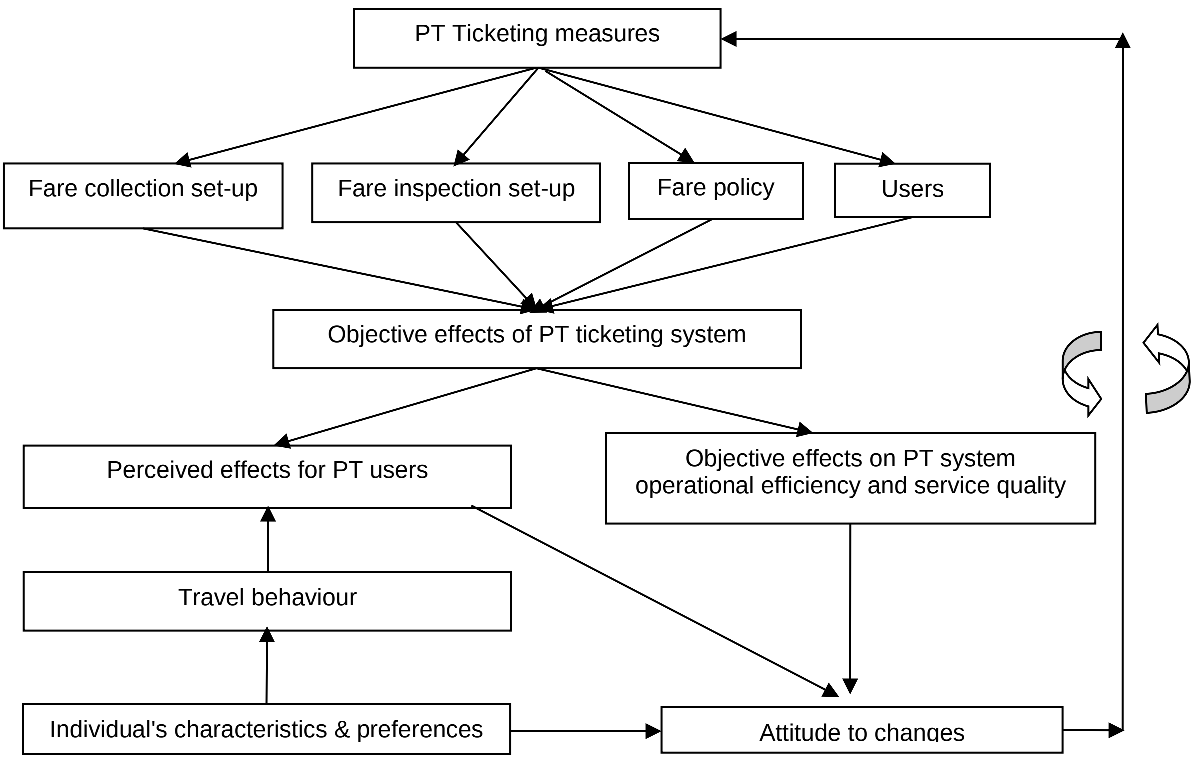

Figure 4. A conceptual framework for factors affecting attitudes towards ticketing

4.3 *Survey design*

Cross-sectional data was collected from 1320 rail commuters via an en-route questionnaire survey along the corridor with the largest proportion of cross-county commuting in Sweden, the Stockholm-Uppsala corridor. The data was collected in autumn 2017 as part of the Movingo integrated ticketing project. This period was appropriate for the survey because the travel demand along the corridor for three consecutive years (2014-2016) showed that demand along the corridor peaks in the autumn. Also, similar travel surveys around Sweden had been conducted within the period September - October (Travel behaviour surveys in Stockholm, 2016 and in Malmö, 2014).

Likert scale statements measuring how an individual commuter evaluates several ticketing attributes were used in the survey. That is, given that a commuter's perception of the different aspects of a given ticketing set-up can be negative, neutral or positive, the overall level of quality of the ticketing system can be measured by averaging the Likert scale scores for the individual commuters and across commuters. Seventeen (17) ticketing attributes were used to evaluate the quality of the ticketing system. They were grouped into two dimensions. One dimension consisted of fare collection attributes, namely: convenience of ticket use, ease of getting ticket information, ticket access time, ease of buying ticket, possibility to buy ticket on-board, ease of using ticket vending machines, flexibility of buying ticket, and ease of retrieving a lost or damaged ticket. The second dimension consisted of fare verification attributes, namely: fare verification by staff, fare verification by bus driver, ease of passing through turnstiles, safety and security when passing through turnstiles, perceived congestion at turnstiles, and perceived delays at turnstiles.

The survey questionnaire had three sections: Section A consisted of eleven close-ended questions focusing on the respondents commuting habits and behaviour; part of section B was made up of nineteen 7-point Likert scale statements measuring attitudes. Finally, section C consisted of six close-ended questions that focused on collecting information on the commuters' sociodemographic characteristics. A pilot survey was first conducted on-board train on 30 commuters to check the appropriateness of the survey design. The results of this pre-test were then used to refine the survey questions.

The survey was carried out within a two-week period during peak travel hours (06:00 –09:00 and 15:00 – 18:00). The questionnaires were randomly distributed to the commuters. To increase the response rate, respondents could choose to return answered questionnaires directly to the surveyors or by self-completion and mail-back at the respondents' convenience. Respondents could also answer the survey online on-board using tablets provided by the surveyors or answer them online at their convenience elsewhere.

Based on the estimated total sample size and the expected response rate of about 35% based on previous surveys (Stockholm county travel behaviour report, 2016), the estimated minimum number of questionnaires that needed to be distributed was 1074. To ensure that the minimum expected number of responses was obtained, 1800 paper questionnaires were distributed during the fieldwork, from September 11th to September 22nd, 2017. A total of 1131fully and partially filled paper questionnaires were returned. This gives an overall survey response rate of about 63%. This is significantly higher than the expected response rate of 35%.

Of a total of 1320 returned paper and online responses, 56 % answered on-board using paper and pencil, 23% answered online and 21% answered by mailback. While most of the respondents opted for the on-board paper survey, the analysis of variance showed no statistically significant effect of the response method on the average commuters' attitudinal scores ($F = 0.864$, P-value $=0.462$). Table 3 summarises the sample distribution of the respondents' characteristics and travel habits. The aggregated sample distributions of the attitudes' measurements are summarised in Table 2, the first ten attributes are grouped as a measure of the users' experiences with fare collection and the last seven attributes are grouped as a measure of their experiences with fare verification. The attributes replacement of damaged ticket (card) and retrieval of lost ticket were not very common experiences among the respondents as 54 – 60% of them did not have opinions on these two attributes.

If the attitudinal questions relate to the same issue, respondents are expected to get similar scores on each question. To confirm this, the Cronbach's α test was used to measure the internal consistency (how closely related the items are as a group) of the set of attitudinal questions measuring the latent constructs for fare collection and fare verification systems, which are directly non-measurable. All the α values are greater than 0.70 (Table 2), suggesting a strong reliability.

4.4 Data analysis

An important issue among researchers is how to best analyse Likert questionnaires. Parametric or non-parametric statistical procedures? Due to the ordinal nature of Likert items, non-parametric inference techniques such as Mann-Whitney U test and Kruskal-Wallis H test are often used. However, de Winter and Dodou (2010), who compared Type I and II error rates of t test and Mann-Whitney U test using five-point Likert items, concluded that the two tests have similar power. On the other hand, a Likert scale is different from a Likert item as it is made up of a series of Likert items that represent similar questions combined into a composite score. This is the case in this study. The most recent comprehensive reviews of the literature concerning the controversy of the appropriateness of using parametric procedures to analyse Likert scale data are provided by Harpe (2015) and Norman (2010). They both strongly confirmed that the use of parametric analytical procedures on Likert scale data is appropriate. Hence, the composite average scores in this study are analysed as interval data using the mean as a measure of central tendency. Parametric inference analysis of the averages of Likert scale samples is quite prevalent in the analysis of attitudinal surveys in the transport sector (Börjesson et al., 2015; Susilo and Cats, 2014; Handy et al., 2005). Common parametric inference techniques include t-test, Analysis of variance (ANOVA) and linear regression procedures.

Table 2. Descriptive analysis of the survey ratings.

Statements (Sample size, n = 1 259)	*Strongly agree 7 – Strongly disagree 1 (Relative frequency %)*							
Ticketing attribute statements (Overall construct reliability, Cronbach's α = 0.83)	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**No opinion (0)**
Relating to fare collection (Cronbach's α = 0.83)								
It is easy to replace damaged ticket	7	5	4	8	5	5	6	60
It is easy to retrieve lost ticket	8	5	6	9	6	5	6	54
I have the flexibility to buy or top up my ticket at any time and any where	17	15	18	16	12	6	7	9
Using a ticket vending machine is easy for me	18	21	20	16	9	4	5	8
It is acceptable that I cannot buy ticket on the bus	20	8	7	10	13	13	20	9
It is easy to get information about available ticket types	25	19	20	14	9	7	5	1
It is easy to buy or top up ticket	26	26	20	12	7	4	3	2
The time it takes to buy or top up ticket is acceptable	27	29	21	11	5	3	2	2
It is acceptable that I cannot buy ticket on the train	29	15	12	13	9	8	11	4
It is easy for me to use my ticket	36	22	16	8	4	2	3	10
Relating to fare verification (Cronbach's α = 0.72)								
Delay level at turnstiles is acceptable	3	7	12	14	17	12	18	18
It is disturbing for me to have my ticket checked by bus driver	5	3	5	6	9	15	49	8
It is smooth for me to pass through turnstiles when I am having luggage, pram, wheelchair or rollator	7	8	14	13	12	10	9	28
Congestion level at turnstiles is acceptable	7	13	19	17	12	8	8	16
I find ticket control by staff on train disturbing	8	5	6	10	10	15	42	3
I do feel safe and secured when passing through turnstiles	22	20	16	13	7	4	3	14
It is smooth to pass through turnstiles	25	22	16	12	6	3	3	12

No opinion (0) responses were excluded in the calculation of the average scores as it indicated that the respondent is yet to experience the given ticket aspect. The Cronbach's α represents the internal reliability of the latent constructs, all values are greater than 0.70, suggesting a strong reliability.

Choosing a 0.05 significance level, all statistical analyses were done using the R programming language for statistical and computational analysis. Given that different commuters have different needs and given that the dataset composed of Likert scale data, differences between the average scores of the different commuter segments were analysed using a two-way ANOVA. ANOVA which has the test statistic F is a well-known statistical method for comparing two or more population means to examine the heterogeneity of the means in studied groups. In other words, for testing for differences among mean values of a dependent variable Y across multiple levels of an independent categorical variable (s) X if: The sample is randomly and independently drawn from the population; Y is continuous and normally distributed (or more accurately, the errors are assumed to be normally distributed); and that X has discrete groups (levels) of homogeneous variances. "ANOVA is the most commonly quoted advanced research method in the professional business and economic literature" (Aczel and Sounderpandian, 2006) and has been used by many authors for the analysis of variance in travellers' attitudes and perceptions (Soltani et al., 2019; Beck and Rose, 2016; Dütschke et al., 2016; Fraszczyk and Mulley, 2017; Malhotra et al., 2017; Pantouvakis and Renzi, 2016; Pedersen and Friman, 2011).

The sample in this study was randomly drawn from commuters along the studied corridor. The Shapiro-Wilk formal test of normality on the mean scores confirmed that the sample did not deviate from the normality assumption of parametric analysis (W = 0.993, p-value = 0.412). Performing the same test on the residuals of the ANOVA results also confirmed that the assumption of normality is valid (W = 0.996, p-value = 0.897).

Table 3. Descriptive analysis of the sample

User characteristics (Sample size, n = 1 320)	*%*	*Commuting characteristics*	*%*
Gender		**Ticket type used**	
Female	56.9	*30 days*	78.1
Male	42.6	*90 days*	1.6
Other	0.5	*One year*	3
Age (Years)		*Other*	17.4
16 – 24	17.8	**Service Provider**	
25 – 34	29.7	*SL/UL (Integrated)*	45.8
35 – 44	20.8	*SJ*	34.1
45 – 54	18.0	*SL*	9.9
55 – 64	11.3	*TiM*	5.5
65 +	2.4	*UL*	4
Monthly gross income in SEK		*Other*	0.6
0–10 000	14	**Commuting frequency (Train)**	
10 001–15 000	7	*1 - 2 days/week*	7.4
15 001–20 000	3	*3 - 4 days/week*	25.4
20 001–25 000	4	*≥ 5 days/week*	58.1
25 001–30 000	11	*Rarely*	5.7
30 001–35 000	14	*Never*	3.4
35 001–50 000	25	**Commuting experience (Train)**	
Over 50 000	15	*< 1 year*	24.3
Do not want to give	7	*1 – 2 years*	22.5
Education		*3 – 4 years*	15.6
Higher education (3 or more years)	57.1	*≥ 5 years*	37.5
Higher education (less than 3 years)	19.0	**Ticket purchase channel**	
High school graduate	21.5	*Vending machine*	31.4
Under High school	1.2	*Sales agent*	20.3
Other	1.3	*Service provider offices*	25.7
Employment status		*Mobile phone*	15

Full-time employed	64.8	*On the internet*	3.6
Part-time employed	5.0	*On-board PT vehicle*	0.2
Full-time student	22.4	*Other channels*	3.8
Part-time student	2.0	**Use of season for other trips**	
Full-time self employed	2.5	*1-2 times a week*	21
Part-time self employed	0.6	*3 - 4 times a week*	8.2
Other (unemployed)	2.7	*≥ 5 times a week*	9.3
Received tax reduction for work trips		*No season ticket*	8.1
Yes	58.8	*Never*	9.5
No	41.2	*Rarely*	44
Travel cost paid by employer		**Commuting route**	
No	91.5	*Stockholm – Knivsta*	13
Partly	4.1	*Stockholm – Märsta*	7
Fully	4.4	*Stockholm – Uppsala*	67
		Uppsala – Märsta	3
		None commuters	11

To analyse the effects of respondents' characteristics, travel behaviour and the survey response method on the average scores, the assumption of homogeneous variance was checked using Levene's Test for equality of variances for all the nineteen (19) independent categorical variables that were used in the ANOVA. This test of homogeneity at 95% confidence interval produced p-values > 0.05 for all the variables except for the categorical variable "frequency of use of season ticket for none work/school trips", which was only significant at 99% confidence interval. The p-values from the Levene test are: Gender (p-value = 0.332), Age group (p-value = 0.706), Education level (p-value = 0.776), Monthly income (p-value = 0.614), Frequency of commuting by train (p-value = 0.578), Frequency of commuting by car (p-value = 0.640), Commuting experience by train (p-value = 0.451), Frequency of use of season ticket for none work/school trips (p-value =0.0028, significant at 99% confidence interval), Received tax reduction for work trips (p-value =0.398), Commuting route (p-value =0.207), Service provider (p-value = 0.464), Ticket type (p-value =0.908), Ticket purchase channel (p-value =0.893), Access mode from home to work or school (p-value = 0.191), Access mode from work or school to home (p-value = 0.418), Self-reported travel time from home to work/school (p-value =0.940), Self-reported travel time from work/school to home (p-value =0.440), Employment status (p-value =0.218), Survey response method (p-value = 0.672).

5. Empirical results

The results of the four sets of hypotheses that were tested are presented in sections 5.1 – 5.3.

5.1 Variability in the perceived quality

This section hypothesizes how a series of categorical variables (income group, commuting route, ticket type, ticket purchase channel, gender, age, level of education, frequency of commuting by train, frequency of commuting by car, train commuting experience, frequency of use of season ticket for none work/school trips, tax reduction for work trips, chosen service provider, access mode, travel time and employment status) could influence commuters' attitudes towards ticketing. Given the perceived quality of the ticketing set-up (measured by the average attitudinal scores) as the dependent variable, a Two-way ANOVA was used to simultaneously test if there is difference in the perceived quality for the different commuter segments. The null hypothesis was that the average perceived quality is the same across all the different user groups (H0: μ1 = μ2 = ... =μn). The alternative hypothesis was that the average perceived quality differs between at least one pair of the commuter groups (HA: μ1 ≠ μ2 ≠ ... ≠ μn). The ANOVA (Table 4) detected significant differences in the average scores due to income, commuting route, ticket type, and ticket purchase channel. Analysis of covariance (ANCOVA) was conducted on these four variables whose main effects were found to be statistically significant in the ANOVA test. However, the test did not detect any significant interaction effects between these variables. Since the ANOVA test detected only the overall differences in the average scores among groups in four of the independent categorical variables that were included in the test, a follow-up statistical test was conducted to examine where, within the pairs of the multiple levels of the independent variables, the differences existed. The Tukey HSD (Tukey Honest Significant Differences) Post-hoc pair comparison detected significant differences in the average scores between: commuters on the Stockholm – Uppsala and Stockholm – Knivsta routes (adjusted p-value = 0.039); the income group 20 001 - 25 000 and the group that did not want to disclose their income (adjusted p-value = 0.067); and commuters using 30 days ticket and those using one year's ticket (adjusted p-value = 0.064). The test did not detect any honest significant differences in the ticket purchase channel groups.

5.2 Perceived quality

Seventeen (17) ticketing attributes were used to evaluate the perceived quality of the ticketing system. The attributes were grouped into six dimensions. The average perceived quality of each dimension is presented in Table 5.

In general, the system's average score indicates that the commuters are fairly satisfied with the entire ticketing set-up. Apart from the mean score of manual fare verification by staff, all the estimated mean scores appeared not to differ much from the neutral value of 4 on the Likert scale of 1 - 7 (Table 2). Are these observed differences due to chance or real? A two-tail t test was conducted to test if these means were significantly different from the neutral value of 4. Two hypotheses are thus defined: A null hypothesis, H0: $\mu 1 = \mu 2 = \ldots = \mu n = 4$, and an alternative hypothesis, HA: $\mu 1 \neq \mu 2 \neq \ldots \neq \mu n \neq 4$. The hypothesis test showed that the p-values for the system's average score, fare collection and automatic verification by turnstiles were far less than 0.000; the null hypothesis is therefore rejected and the alternative hypothesis that the mean scores for these dimensions are not equal to 4 is accepted. Hence, the observed differences could not have been due to chance but rather some systematic influence. There was however no evidence to reject the null hypothesis for the dimensions: fare payment on-board (p-value = 0.783) and fare verification (p-value = 0.438). It is therefore believed that the mean scores for these two dimensions are neutral in value.

Table 4. ANOVA results. *Significance codes: '*' 0.05*

Commuter segments *(Sample size, n = 221)*	**Df**	**Sum Sq.**	**Mean Sq.**	**F value**	**Pr(>F)**
Gender	1	0.03	0.0344	0.055	0.8154
Age group	5	3.08	0.6168	0.981	0.4316
Education level	4	4.07	1.0173	1.618	0.1729
Gross monthly income	8	10.86	1.3576	2.159	0.034*
Commuting frequency (Train)	4	4.88	1.2191	1.939	0.1071
Commuting frequency (Car)	4	2.81	0.7029	1.118	0.3505
Train commuting experience (years)	3	2.19	0.7308	1.162	0.3264
Use of season for none work/school trips	5	1.85	0.3697	0.588	0.7092
Received tax reduction for work trips	1	1.07	1.0655	1.694	0.1951

Commuting route	3	5.94	1.9811	3.15	0.0269*
Service Provider	5	1	0.2006	0.319	0.9009
Ticket type used	3	6.09	2.0311	3.23	0.0243*
Ticket purchase channel	5	7.84	1.5671	2.492	0.0338*
Access mode (home - work/school)	6	2.72	0.4529	0.72	0.634
Access mode (work/school - home)	6	5.82	0.9703	1.543	0.1682
Self-reported travel time (work/school - home)	2	1.47	0.7329	1.165	0.3147
Self-reported travel time (home - work/school)	2	0.48	0.2388	0.38	0.6847
Employment status	5	2.73	0.547	0.87	0.5031
Survey response method	3	1.63	0.5431	0.864	0.4616
Residuals	**145**	**91.18**	**0.6289**		

5.3 Preference for fare verification technique

Since the commuters tend to have a mildly positive attitude towards automatic fare verification by turnstiles (mean score = 4.4) but a negative attitude towards fare verification by staff (mean score = 2.9), the commuters' responded to the question *"I prefer ticket checking by staff to that by turnstiles"* was further investigated. Out of a total of 814 observations in the sample, 64% answered no and 36% answered yes. A One-way chi-squared (χ^2) goodness of fit test with random expected values was conducted to determine if the commuters showed any preferences for fare verification technique. That is, it is assumed that both options were chosen randomly (equally or 50% of the time) and that the observed values showed no preference for one option over another. The expected frequencies were greater than five for both categories. The test showed statistically significant association in the commuters' preference for fare verification, χ^2 (df = 1, N= 814) = 66.123, p-value = 0.000. There is therefore enough evidence to reject the null hypothesis of no preference for fare verification options and to believe that most of the commuters showed preference for automatic fare verification by turnstiles compared to manual verification by staff.

Table 5. Dimensional average of attitudinal scores on a scale of 1 to 7

Attitude dimension	Mean	Standard dev.	95% Conf. interval
Fare collection	4.71	1.10	4.56 - 4.85
Payment on-board	3.96	1.94	3.71 - 4.22
Fare verification	3.95	0.96	3.82 - 4.08
Manual verification by staff	2.92	1.71	2.70 - 3.15
Automatic verification by turnstiles	4.36	1.2	4.20 - 4.52
System's average score	**4.40**	**0.85**	**4.28 - 4.51**

6. Discussion

The research questions are discussed separately in this section based on the results and previous research works.

What factors affect commuters' attitudes towards ticketing? The analysis suggests no evidence of statistically significant effect of gender, age, level of education, frequency of commuting by train, frequency of commuting by car, train commuting experience, frequency of use of season ticket for none work/school trips, tax reduction for work trips, chosen service provider, access mode, travel time and employment status on the attitudes. Users attitudes are heterogeneous based on many factors. It was suspected that all factors included in the analysis could induce heterogeneity in the commuter's attitudes towards ticketing based on our conceptual framework (Figure 4) and previous research works. Whilst the commuters were quite uniform in how they evaluated the attitude object in question (ticketing), it is interesting that income, commuting route, ticket type and ticket purchase channel influenced their attitudes. The commuting route constitutes the PT environment and previous works confirmed that environment can affect travel behaviour and attitudes. The routes that were included in this study differ in aspects that may influence attitudes such convenience of ticketing, price, comfort, safety, aesthetics, reliability, frequency of service, accessibility, information provision, ease of transfers. The study by Graham and Mulley (2011) shares similarity with this study. They surveyed PT users to study their behaviour before and after the implementation of prepaid tickets in New South Wales (Australia). They confirmed that significant difference existed in the characteristics of passengers using multimodal tickets and pay-as-you-go passengers due to income and whether a journey involved transfer or not. Ticket purchase channel is associated with convenience and speed of purchase. The effect of the commuter's attitudes by ticket purchase channel was hence expected as the use of season tickets reduces the frequency of ticket purchase. For instance, using an annual ticket reduces the frequency of ticket purchase twelve times as compared to using a monthly ticket. An annual ticket is thus twelve times better in terms of the convenience of purchase and saving the time spent on ticket purchase. The effect of ticket purchase channel on users' attitudes to ticketing was also evidenced in a recent study by Allen et al. (2019), where passengers in the 35 – 44 age group were found to have the highest demand for well-functioning ticket vending machines.

What are the attitudes of PT commuters towards PT fare collection and verification? The results suggested that the commuters were slightly positive towards ticketing in general. Fare collection and fare verification (Table 5) were, however, evaluated differently by the commuters. They were slightly positive towards fare collection but neutral to fare verification. While we are yet to find previous studies relating to attitudes to PT fare collection and verification, the results have two main implications: that the perceived quality status of the current ticketing system is neither good nor bad and that users care about the quality of all aspects of PT ticketing and not just fares. For instance, the variations in the perceived quality of fare collection and fare verification in the study indicates that the fare verification aspects of the ticketing system under consideration need to be prioritised in improving the ticketing system and, thereby, the quality of the PT system.

Do commuters have preference for the current fare verification options? The findings further suggest that the commuters have a slightly positive attitude to automatic ticket checking by turnstiles but react negatively to manual ticket checking by staff. Fare verification by turnstiles is obviously associated with barrier effects while fare verification by staff encourages staff presence within PT environments. Staff presence offers many benefits such as enhanced perceived security and easy access to information. It was thus expected that the commuters would be more interested in interacting with fellow humans than machines. Somewhat surprisingly, the data suggested the opposite. In the case of Madrid's Metro system, Allen et al. (2019) also reported that PT users evaluated the operation of turnstiles more positively than the kindness of security staff. A further investigation on this issue due the unexpected results confirmed that most of the commuters (about 71%) chose automatic fare verification by turnstiles over manual verification by staff. This may be explained by the fact that most commuters use their in-vehicle time to work or perform other activities and hence may not like to be interrupted by staff for fare verification reasons. Another possible explanation could be that the commuters have both a high level of perceived security and enough information about their commuting routes and, therefore, perceive the presence of staff to be less important. This might be expected not to be the case, however, for less frequent PT users.

Even though most of the commuters prefer fare verification by turnstiles, PTI (2010) confirmed that the use of turnstiles in metro and some BRT systems is relatively less effective in combating fare evasion. Additionally, it is obvious that turnstiles are associated with barrier effects resulting in: creation of queues during peak hours; delays due to faulty turnstile machines; minor accidents which may cause injuries or damage to property; fare evaders disturbing compliant users through piggy-backing or tailgating and turnstile jumping; inconveniences for travelers carrying luggage or similar loads; travelers with prams; travelers in wheel chairs; visually challenged travelers; older people and so on. Turnstiles may also pose a major risk during stampede in the event of disaster or terror attack in crowded transit stations.

Consequently, considering the commuters negative reaction to fare verification by staff and the challenges associated with fare verification by turnstiles, a logical extension of the analysis is to think of an alternative approach to fare verification, even though this is beyond the scope of our data. Comparatively, modes like private automobile and cycling hardly have ticketing requirements. This suggests that both fare verification by staff and turnstiles are sources of inconvenience for commuters. A smarter fare verification approach where fare verification is done passively without the active participation of the user may be a suitable future option. The demand for such a passive fare verification system was also mentioned in TRCP report 117 (2015), envisaging passive interaction between users' smartphone and readers located at the transit system entry points or at the doors of PT vehicles.

Does commuter familiarity with the policy of "No-ticket-purchase on-board train" breed acceptance? The possibility to purchase ticket on-board PT vehicle possibly makes tickets more accessible to users even though this might have some negative consequences on the efficiency of PT operations. As service providers in Sweden advocate "No-ticket-purchase on-board train", it was expected that PT users would advocate for the flexibility to be able to buy a ticket on-board PT vehicle or elsewhere. It however turned out that the commuters' reaction to this was neutral. This might mean that many PT commuters have probably adjusted to this policy of not being able to buy tickets on-board as many PT service providers in Sweden have eliminated payment on-board trains. Payments on-board buses partly exist today. Cash payments on-board buses are not allowed whilst payment with a bank card is penalised by many service providers. Another reason that could account for this is that most commuters in Sweden are more likely to purchase season tickets (most of which are monthly tickets) and thus have less need to purchase a ticket on-board, compared to none-frequent users.

7. Conclusions

Commuters' attitudes and perceived quality of PT fare collection and fare verification systems were explored in this study with the aim of evaluating the quality of the ticketing set-up before and after the implementation of the Movingo integrated season ticket project. Attitudinal surveys were administered to PT commuters along the corridor with the largest proportion of cross-county commuting in Sweden (Stockholm – Uppsala) using PT ticketing as the attitude object. The main findings from this study suggest that:

Commuters' attitudes to ticketing were generally affected by income, commuting route (location), ticket type and ticket purchase channel, implying that these are relevant variables to be considered in evaluating the quality of a ticketing set-up.

Fare collection and fare verification systems are an integral part of PT service quality and should be analysed separately in the evaluation of PT service quality as they are perceived differently by users.

Familiarity did not necessarily breed acceptance as most commuters are familiar with the policy of 'No-ticket-purchase on-board PT vehicle' and still remained neutral to it. This provides a good example for PTA's intending to implement this kind of policy in the future.

Finally, most commuters prefer fare verification by turnstiles to manual fare verification by staff and did not like to be interrupted by staff for fare verification reasons. The commuters' perceived the inconvenience emanating from the ticketing system to be at an acceptable level even though some improvement measures are required for the fare verification aspect. This provides up-to-date information on the quality status of fare collection and verification within the study area for evaluating the perceived quality of fare collection and verification set-ups before and after the implementation of the Movingo integrated season ticket project. The commuters' preference for automatic fare verification suggests a policy direction for improving fare verification. As PT systems are increasingly being automated, a smarter fare verification approach, where fare verification is done passively without the active participation of the user, may be a suitable future option for reducing the burden of fare verification on commuters.

The study focused on commuters' attitudes to ticketing and cannot be used to generalize PT users' attitudes to ticketing. Further study on how non-commuters react to fare collection and verification is hence recommended. Future research work is also recommended on: Commuters preferred choice of fare verification, by extending the choice set – for instance by only staff, by only turnstiles, by both staff and turnstiles, by passive (smart) verification or no fare verification at all; The feasibility of the proposed passive automatic fare verification approach; and the estimation of the effects of different ticketing aspects on the overall perceived quality of PT ticketing to identify important aspects of ticketing to be included in studies relating to an overall measure of PT service quality.

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