Seamless ticket inspection: Proposing and exploring users' reaction to a next generation public transport ticket inspection solution

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ABSTRACT

Ticket payment and inspection are the two main dimensions of public transport ticketing for users. Both research and technological advances have focused mainly on improving the former. In contrast, this paper explores users' preferences for ticket inspection options and the associated factors that influence their likelihood of accepting seamless ticket inspection. This is motivated by the general lack of research on users' preferences and satisfaction for ticket inspection alternatives, and the need to use established and emerging smart card and mobile ticketing technologies to develop smarter, seamless and more convenient ticket inspection solutions.

The dataset is part of the data that was collected along the Stockholm – Uppsala corridor for the purpose of evaluating the Movingo integrated ticketing scheme. The number of respondents in 2017 was 450 and 165 in 2018. McNemar's test was conducted to test for difference in the respondents' choice proportions between ticket inspection by turnstiles and staff in the two samples. By extending the choice set to include the hypothetical option of seamless ticket inspection in the second survey, a one-way chi-squared goodness of fit test was conducted to determine if the respondents still showed preference for ticket inspection alternatives. Since it was only the second dataset that contained all the four ticket inspection alternatives, this cross-sectional dataset was used to estimate one multinomial and two nested logit models to analyse users' choice among the ticket inspection alternatives.

The findings suggest that given only turnstiles and staff as the only ticket inspection alternatives, the respondents' choice of ticket inspection by turnstiles over that by staff did not change over time. However, given five alternatives, majority of the respondents opted for seamless ticket inspection and major user groups such as females and young people have a high tendency to accept it. Further research is recommended on particular aspects of the envisaged seamless ticket inspection.

Keywords: Commuter, fare collection, fare verification, ticket inspection, fare evasion, ticket forgery, convenience

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1 INTRODUCTION

Public transport (PT) ticketing is widely acknowledged to have impacts on user convenience (Zalar et al., 2017; Wardman, 2014; Anderson et al., 2013; Vuchic, 2005). Significant investment into improvements in ticketing procedures around the world during recent years strongly indicates that operators also view ticketing as a burden on users. This burden can be understood as a disutility, stemming from the fact that ticketing is not an end by itself but a means of accessing the PT service. Making the PT service attractive thus requires attractive ticketing so as to minimise this disutility.

PT ticketing has two main dimensions for users - ticket payment and inspection. Both research and technological advances have tended to focus more on improving the former, making it relatively more convenient for users to choose among different payment options and to travel across different service providers seamlessly. The opposite is true about ticket inspection, as users generally lack the opportunity to choose how they want their tickets to be inspected. Even if users were given the opportunity to choose their preferred ticket inspection approach, the current choice set would be limited to ticket inspection by personnel and/or turnstiles.

Considering the increasing digitalisation and automation of PT systems globally, we propose that further attention be given to using established and emerging smart card and mobile ticketing technologies to develop smarter and more user-convenient ticket inspection solutions for passive ticket inspections without the regular active involvement of users. This study, therefore, explores seamless ticket inspection as the next generation ticket inspection solution.

The principal purposes of ticket inspection are to combat fare evasion (usage of PT service without paying for it) and ticket forgery (production and usage of fake tickets). Understandably, these are of great concern for public transport service providers (PTSP) as it is common in cities in particular (Delbosc and Currie, 2019, Wilhelm et al, 2018). Delbosc and Currie (2019) grouped the shift in global fare evasion research into three perspectives: the conventional PT system perspective, the customer profiling perspective and the customer motivation perspective. Similarly, Public Transport International, Bonfanti and Wagenknecht (2010) identified ticket inspection by staff, investing more power in inspectors, partnership with the police, communication, on-board technologies such as video surveillance, and access control by the use of turnstile as the different fare evasion measures used by PTSP. Both studies also highlighted the strengths and weaknesses of these perspectives and measures.

Mass Transit (2016) identified fare evasion and user satisfaction as two of the top three challenges that new ticketing technologies need to address. Yet, very limited research has looked into the customer convenience and satisfaction perspectives of ticket inspection such as users' preferences and satisfaction with current ticket inspection approaches. Interestingly, we are also yet to find previous research on seamless ticket inspection in the transportation literature. TRCP report 117 (2015) briefly mentioned smart ticket inspection with passive interaction between users' smartphone and readers located at the transit system entry points or at the doors of PT vehicles, yet research on seamless ticketing has mainly focused on seamless ticket payment issues.

Current ticket inspection enforcement can provoke violent reactions from users such verbal insults and attacks on staff and compliant passengers (Delbosc and Currie, 2019; Wilhelm

et al, 2018; Bonfanti and Wagenknecht, 2010). Alhassan et al (2019) also pointed out that PT commuters were slightly positive towards automatic ticket inspection by turnstiles but negative towards manual ticket inspection by staff. Most of the respondents (71%) in the study also chose automatic ticket inspection by turnstiles over manual inspection by staff. Similarly, in the case of the Madrid's Metro system, PT users evaluated the operation of turnstiles more positively than the kindness of security staff (Allen et al., 2019).

Inspection via turnstiles, however, has a number of disadvantages. Bonfanti and Wagenknecht (2010) pointed out that the use of turnstiles in metro and some BRT systems is actually relatively less effective in combating fare evasion; probably one of the reasons why many stations equipped with turnstiles are also staffed. Additionally, turnstiles are expensive to build and maintain, they can be visually and physically intrusive and may be impractical to implement under certain conditions (Delbosc and Currie, 2019). This means that they are not all-inclusive and are associated with barrier effects that may result in: the creation of queues and reduction station capacity particularly during peak hours; delays due to faulty turnstile machines; minor accidents which may cause injuries or damage to properties; fare evaders disturbing compliant users through piggy-backing or tailgating and turnstile jumping; inconveniences for travelers such as those carrying luggage or similar loads, prams, physically and visually challenged travelers (particularly wheel chair users) and older people. Turnstiles may also pose a major risk during stampede in the event of disaster or terror attack in crowded transit stations.

Given the challenges of current ticketing inspection approaches, the general lack of research on users' preference and satisfaction with ticket inspection, and the need to use established and emerging smart card and mobile ticketing technologies to develop a smarter, seamless and more convenient ticket inspection solution, the two research questions driving this study are:

1). What are PT users' preferences for ticket inspection alternatives given current and future scenarios?

2). What factors are associated with their likelihood of accepting a seamless ticket inspection alternative?

The two main contributions of the study are:

1). It provides new information on how PT user characteristics may influence their preferences for ticket inspection alternatives, which is relevant for both researchers and practitioners for developing more user focused PT ticket inspection systems.

2). In addition to suggesting seamless ticket inspection as the next generation ticket inspection approach in the future world of highly digitalised and automated transport systems, the study also gives insight into its acceptance by some major PT user groups. Its acceptance and technical feasibility are central to its development and operation.

The rest of the paper is organized as follows. The next section describes the study area. Section 3 describes the survey design and analysis. Section 4 presents the empirical results and discussion. Section 5 contains some conclusions and recommendations.

2 THE CASE STUDY AREA

The dataset used in this study was part of the data collected along the Stockholm – Uppsala corridor, which has the largest share of cross-county commuting trips in Sweden, for the purpose of evaluating the Movingo integrated ticketing scheme. Movingo is a

smartcard and mobile phone based multiple-county commuting ticket that applies to both intercity and intracity bus and train services within the Mälardalen region of Sweden. This corridor is mainly served by the National Swedish Railways (SJ), the Stockholm and Uppsala counties public transport authorities (PTAs). While SJ and the Uppsala county PTA use only staff for fare inspection, the Stockholm county uses both staff and turnstile. Also, while Stockholm city is heavily "turnstiled", Uppsala city is zero "turnstiled", with commuters experiencing both systems daily. This makes this area a suitable case for analyzing ticket inspection.

3 METHODS

3.1 Survey design

To investigate user preferences for ticket inspection options and the propensity for a seamless ticket inspection among PT users, we extended the work of Alhassan et al. (2019) that investigated commuter' preference for the two most widely used ticket inspection approaches (staff and turnstiles), along the Stockholm-Uppsala corridor in relation to the Movingo integrated ticketing scheme. That is, two survey datasets were collected along this corridor, containing 450 respondents in 2017 and 165 respondents in 2018. **Figure 1** illustrates the respondent's revealed choices in the two samples given staff and turnstiles (the two main current ticket inspection approaches). Over 60% of the respondents preferred ticket inspection by turnstiles to that by staff in both samples. As shown in **Figure 2**, with the same respondents, the ticket inspection choice set, which contains only two alternatives in the first survey (staff and turnstiles), was extended to five in the follow-up survey (i.e. automatically without a user direct involvement/seamless ticket inspection, by both staff and turnstiles, only by staff, by only turnstiles, no to ticket inspection). While just 1 out of 25 respondents in the sample opted for no ticket inspection at all, 1 out of 3 of them was uncertain about their preferred ticket inspection option, 1 out of 4 respondents preferred none existing seamless fare inspection.

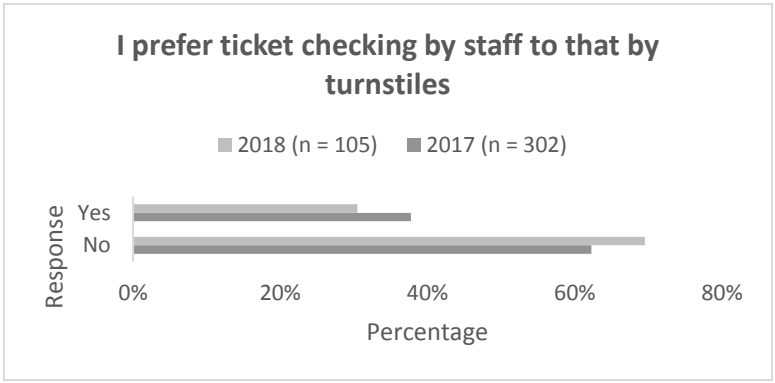

Figure 1: Commuters' revealed choice between ticket inspection by staff and by turnstiles in a two-wave survey

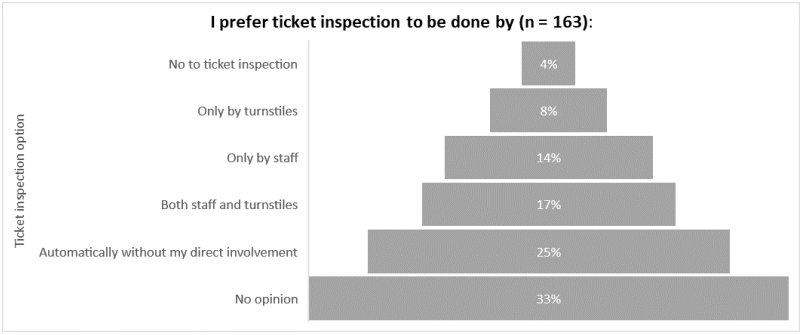

Figure 2: Stated choice of ticket inspection options among PT commuters

3.2 Analysis

Given the two samples, the McNemar's none-parametric test was first used to test for difference in the proportion of respondents who chose between the current two main ticket inspection verification approaches (staff and turnstiles). Same respondents in the two surveys were considered in this analysis.

By extending the choice set to include the hypothetical option of seamless ticket inspection in the second survey, a one-way chi-squared ($\chi 2$) goodness of fit test with random expected values was conducted to determine if the respondents still showed preference for any of the ticket inspection options.

It was only the second dataset that contained all the four ticket inspection alternatives, hence, only this cross-sectional dataset was used to estimate one multinomial (MNL) and two nested (NL) logit models to analyse the characteristics that correlated with the users' ticket inspection choice.

Since some of the alternatives seemed to be more related and thus more likely to share unobserved effects in their random error terms, NL models with two nesting structures were considered (**Figure 3** and **Figure 4**), The alternatives "staff and turnstiles", "turnstiles only" and "staff only" involves direct user involvement in the ticketing inspection process, and were therefore put into the same nest in the nesting structure one (**Figure 3**). Similarly, the alternatives "Seamless ticket inspection" and "no ticket inspection" do not require regular direct involvement of user in the ticketing inspection process, and were hence put in to a nest in the second NL (**Figure 4**). Since the individuals' characteristics do not vary over the five alternatives, they could enter any of the five utility functions in the model specification. The explanatory variables that were available for the modelling included gender, monthly income, education level, their response to whether PT should be made free and fully financed via tax (i.e. whether they are advocates of "free PT" or not), their perceived door-to-door travel time from home to work (self-reported), age, and ticket type. All categorical explanatory variables were dummy coded, assuming non-linearity in their levels.

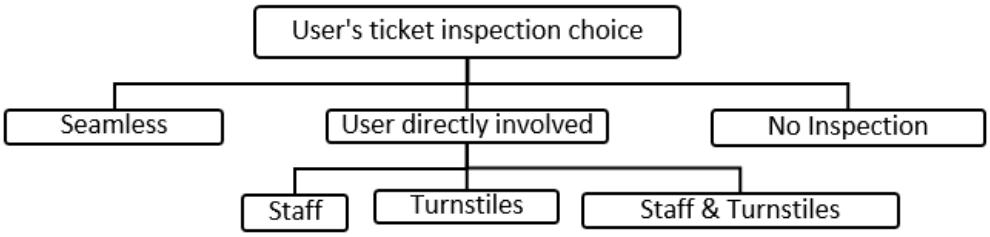

Figure 3: Nested logit structure 1 for ticket inspection (model NL1)

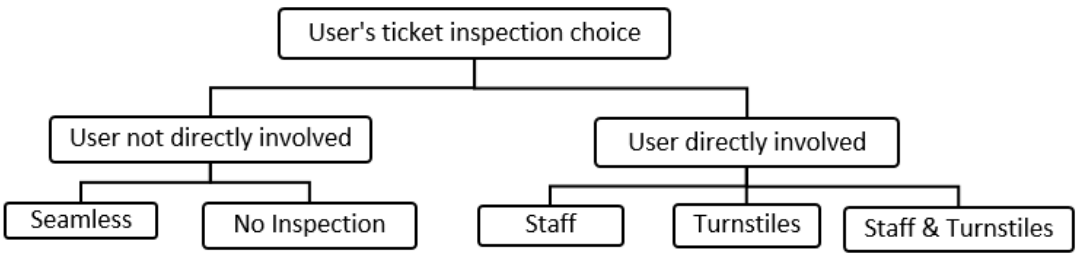

Figure 4: Nested logit structure 2 for ticket inspection (model NL2)

Table 1: Results of the estimated models (*The base alternative is "Both staff and turnstiles" (Status quo), Significance codes: 0.01 '***', 0.05 '**', 0.1'*')*

		MNL	*NL1 (one nest)*	*NL2 (two nests)*
Number of individuals	110			
Estimated parameters		14	13	12
LL(final)		-123.58	-130.03	-145.44
Rho-sq (0)		0.30	0.27	0.18
Adj. rho-sq (0)		0.22	0.19	0.11
Likelihood ratio test statistics {-2(LL of NL1/NL2 -LL of MNL)}		-	12.91 (df = 1, p-value = 000)	43.73 (df = 2, p-value = 000)

	Seamless ticket inspection			**No ticket inspection**			**Only by staff**			**Only by turnstiles**		
	MNL	**NL1**	**NL2**	**MNL**	**NL1**	**NL2**	**MNL**	**NL1**	**NL2**	**MNL**	**NL1**	**NL2**
Variables	*Value (t-stat)*	*Value (t-stat)*	*Value (t-stat)*	*Value (t-stat)*	*Value (t-stat)*	*Value (t-stat)*	*Value (t-stat)*	*Value (t-stat)*	*Value (t-stat)*	*Value (t-stat)*	*Value (t-stat)*	*Value (t-stat)*
(Intercept)	-0.2312 (-0.61)	-0.1032 (-0.06)	-0.8176 (-2.17**)	-1.6315 (-1.48)	1.8926 (1.15)	-1.0685 (-1.75)	0.2465 (0.76)	-2.7659 (-1.15)	0.0066 (0.34)	-2.3767 (-3.26***)	-16.7691 (-1.61)	-0.0184 (-0.38)
Logsum parameter		6.3324 (2.15**)	-3.7078 (-1.35) 6.2028 (3.22***)									
Age (Years)												
16 - 34	2.0987 (3.82***)	-11.4563 (-11.97***)	2.1602 (4.11***)	-8.1648 (-7.45***)						-11.4491 (-14.24***)	-20.7299 (-2.48**)	
35 - 54 (base)												
55+	2.4586 (3.18***)	6.9638 (3.36***)	0.6231 (1.11)	4.2729 (3.39***)						4.3368 (4.47***)	20.0021 (1.86*)	
Monthly gross income in SEK												
0000 - 20000							-1.5665 (-1.92*)	-4.9762 (-2.07**)	-0.0382 (-0.39)			
20001 - 35000							-1.0110 (-1.41)	-0.6545 (-0.40)	-0.0264 (-0.35)			
Over 35000 (base)												
Gender												
Male	-0.9280 (-2.00**)	-1.5370 (-1.66*)	-0.8884 (-1.95*)									
Female (Base)												
Home to Work Door-to-door travel time(Respondents self-reported)				-0.0218 (-11.01***)	0.0050 (0.42)	-0.0189 (-3.27***)						

4 EMPIRICAL RESULTS AND DISCUSSION

4.1 Preferences for ticket inspection options

A McNemar's Chi-squared value (with one degree of freedom) of 0.5926, with an associated p-value of 0.4414, suggests that there was no statistically significant difference in the respondents' preference for ticket inspection in the two dependent datasets. It is thus believed that most of the commuters still prefer automatic ticket inspection by turnstiles over manual ticket inspection by staff over time.

With the extended choice set of five ticket inspection options in the follow-up survey, the One-way chi-squared ($\chi 2$) goodness of fit test showed statistically significant association in users' preference for the ticket inspection options, that is, $\chi 2$ (df = 4, N= 110) = 31.727, and p-value = 0.000, suggesting that most of the respondents showed preference for seamless ticket inspection over current approaches. The "No opinion" responses were removed from this analysis since they were uncertain and the analysis focuses on how user characteristic correlates with ticket inspection choice.

4.2 Factors associated with users' choice of ticket inspection approaches

Table 1 shows the results of the estimated MNL and NL models, given ticket inspection choice as the dependent variable and a set of user characteristics as the explanatory variables. The parameter sign were generally similar in all the three models. Given the data in this study, The MNL model provides the best fit model by examining the likelihood ratio test results in **Table 1**. The logsum parameters for both nested models fall outside the interval [0, 1], which is a precondition for the validity of nested logit models (Koppelman and Bhat, 2006). In addition to the MNL providing the best fit for the dataset, the inconsistence of the logsum parameter estimates with the NL theory further motivated the rejection of the estimated NL models.

The results suggest that PT users in the age category 16-34 years and 55+ years are more likely to accept seamless ticket inspection relative to people in the age category 35-54. As most young people tend to like hi-tech applications, their choice for seamless ticket inspection was expected. It is however, surprising that people who are 55 years and above also preferred seamless ticket inspection. This may be due to their general need for convenience and calmness. Similarly, females are more likely to choose this new approach relative to males. Given that more females patronize PT services more than males in the study area, this implies this area has a good potential for implementing seamless ticket inspection. With respect to income, very high income groups have a higher propensity to choose ticket inspection by staff. This could be due the fact that people with very high often travel with first class train tickets. Thus, often getting the opportunity to enjoy services from staff. PT users with perceived short door-to-door travel time opted for no ticket inspection. This is not very surprising given they have short travel distances and any encounter (s) with ticket inspectors or delays at turnstiles may increase their travel time.

5 CONCLUDING REMARKS

Using the Stockholm - Uppsala corridor in Sweden, this study was conducted to analyze PT users' preference for ticket inspection alternatives and their reaction to seamless ticket inspection, the next generation ticket inspection solution, and to analyse some associated factors that can influence users' choice of ticket inspection. The findings suggest that:

- Given only turnstiles and staff as the only ticket inspection alternatives, the McNemar's Chi-squared test confirmed that the respondents' choice of ticket inspection by turnstiles over that by staff did not change over time.

- However, by extending the choice set to five alternatives, majority of the respondents opted for seamless ticket inspection.
- Major PT user groups such as females and young people have a high tendency to accept seamless ticket inspection, implying that there is a potential market for its implementation
- People in the high income class are more likely to choose ticket inspection by staff
- Users' preference for ticket inspection alternatives correlates with their characteristics. Suggesting that as PT users generally have the freedom to choose how to purchase their tickets, most of them will embrace the freedom to choose how their tickets should be inspected.

Given that the study focused on a corridor, with most of the respondents being commuters, we recommend that the analysis be extended to a wider area and wider PT users. We also see the need for research on the potential for seamless ticket inspection to reduce or prevent hostilities between users and ticket inspectors, the acceptable number of ticket inspections users expect per trip or per day, as well as the technical feasibility of seamless ticket inspection.

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