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Gender Inequality in Safety and Security Perceptions in Railway Stations

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Abstract: Recent studies have shown that gender is the personal aspect that mostly affects mobility patterns and travel behaviors. It has been observed, for instance, that female perception of unsafety and insecurity when traveling using public transport forces them to make unwanted travel choices, such as avoiding traveling at certain times of day and to specific destinations. In order to improve the attractiveness of public transport services, this gender gap must not be overlooked. This paper aims at contributing to research in gendered mobility by investigating differences in safety and security perceptions in railway stations, and by identifying which policies could be effective in bridging any existing gap. The methodology includes the collection of disaggregate data through a mixed Revealed Preference/Stated Preference survey, and the estimation of fixed and random parameters behavioral models. Results from a medium-sized Italian railway station show that female travelers feel safer in the presence of other people; they prefer intermodal infrastructures close to the entrance of the station and commercial activities in the internal premises. Moreover, unlike male travelers, they do not appreciate the presence of hedges and greenery outside stations.

Keywords: gendered mobility; risk perception; railway station design; mixed logit models; RP/SP survey

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1. Introduction

It is well-established in the literature that transport policies have relevant impacts on societal aspects related to distributive justice, equity and social inclusion [1]. The classification of transportation equity into two broad categories is commonly accepted [2]: horizontal equity, so-called egalitarianism, means treating everyone equally, regardless of factors such as race, gender, and age; and vertical equity, also referred as social inclusion, means favoring disadvantaged groups, with regard to income, social class, needs, and the ability to move, in order to compensate for overall inequalities. This paper focuses on one specific aspect related to vertical equity, i.e., the gender inequality in the perception of safety and security in the train stations and terminals, with the aim of identifying those factors that need to be taken into consideration in order to design measures that can guarantee an equal access to rail transport.

Safety and security are two distinct concepts whose meaning is much debated in the literature, as interpretations can vary between research disciplines and the reference context. A definition used by many in the transport sector describes safety as the condition of being protected from danger or harm caused by an unintentional accidental event. While a common definition of security is the state of being protected from threat or damage caused by an intentional criminal act. Examples of accidents are falls, collisions, and slips, while criminal acts include harassment, assault, theft, and robbery. However, it is not just a matter of protection from injury or crime, because even simple rude behaviors, such as bumping, shoving, and cursing, can escalate into something worse [3]. The two concepts, therefore, refer to all those risks that can damage the personal properties of individuals or their physical and mental health.

Many transport researchers have highlighted how safety and security are primary needs of travelers [4,5], especially when it comes to Public Transport (PT) users. This recommends to transport operators and planners that, in order to increase the attractiveness of PT, it is necessary first of all to ensure adequate safety and security conditions, even before a convenient, efficient, and comfortable service [6]. Furthermore, passengers expect these conditions to be guaranteed throughout the entire journey [3]: while accessing a transport node (e.g., bus stop, metro station or railway terminal), while waiting for the ride, when aboard the vehicle, and during the egress from a transport node.

A further issue is that the condition of being protected, i.e., actual safety and security, does not necessarily correspond to the condition of feeling protected, i.e., perceived safety and security [7]. A gap exists between the actual level of safety and security provided by the built environment, achieved with the implementation of prevention measures and protective devices, and the travelers' perceived level of safety and security, which also depends on subjective factors such as socioeconomic characteristics, personal attitudes, travel habits, and past victimization experiences. The goal, therefore, must not only be to minimize the likelihood of unexpected and unwanted events occurring, by improving actual safety and security, but should also be to make people feel safe and secure, preventing individuals from having negative and distorted perceptions about transit environments.

Fear of not being safe and secure affects mobility patterns. In fact, a sense of insecurity could force individuals to adopt some mobility behaviors in contrast with the travel choices they would really like to make. Clear examples are people who avoid using PT services at certain times of day (early in the morning, during rush hours, late at night, etc.), or those who refuse to take public transport and prefer private vehicles in order to avoid contact with strangers and waiting places that are dangerous, or have a reputation for being so (as they are difficult to reach, degraded, not very popular, etc.).

Since mobility is a right of every individual, there should be no limitations of any kind, least of all if caused by the illegal behavior of other people. Everyone should feel free to travel as they see fit; thus, no one should preclude themselves from using PT services.

Several studies in the field of mobility of people have shown that some social groups are more prone than others to have concerns and anxiety about the occurrence of unpleasant events due to a lack of safety or security in transit environments [7–10]. In addition, many have proven that gender is by far the most significant and relevant factor compared to other personal factors [11–13]. Women are more affected by the fear of not being safe and secure than men [14–16], and, as a consequence, women more often feel obliged to take precautions that will inevitably influence their travel behavior [17–19], such as avoiding certain times of day, destinations, routes, transport modes, transfers [20,21], or approaching waiting times with apprehension and experiencing anxiety [14].

However, there are also studies in the literature that refute the hypothesis that women generally perceive transit environments as less safe and secure than men [22–24]. Indeed, some suggest that men, in an attempt to show others an appearance of strength and masculinity, may deny their own fears or may partially hide them [22]. Others argue that it is not gender itself, but other personal factors typical of women that indirectly influence the perceived safety and security; thus, highlighting the existence of latent variables and a more complex construct that justifies the gender differences in perception [23]. However, at the same time, these studies do not exclude that there may be gender diversities in the reaction to safety and security measures implemented in transit environments. For example, the presence of a security officer may not necessarily be perceived equally by males and females.

Therefore, despite a large number of articles in the literature from different research disciplines, the debate on the existence of gender differences on perceived safety and security is still open. Furthermore, there is still a lack of knowledge regarding what the preventive measures are, as well as the protective provisions and, more generally, the requirements demanded by women so that a public transport environment can be considered safe and secure.

This paper aims at filling the existing gap in research by assessing travelers' risk perception indoor and outdoor a train station, emphasizing any heterogeneity due to gender differences. Furthermore, it intends to distinguish which strategies are most effective in improving females' sense of being in a safe and secure railway station.

The behavioral models, estimated on data collected with an on-site survey in a medium-sized Italian railway station, clearly show a different way of perceiving the transit environment by women compared to men. In the case study, gender is indeed the most explanatory personal factor of the variability of the perceived level of safety and security, and it is also evident that some factors of the built environment are preferred by women more than others, or vice versa. This recommends decision makers and transport planners to seriously consider the possibility that risk perception is gendered. Therefore, for those aiming to increase the overall assessment of the perceived safety and security of a transit environment, it should be clear that it may be more cost-effective to spend resources to improve women's perception of risks, as they are the segment of users who, on average, feel less safe and secure, and more afflicted by anxiety and apprehension. Consequently, they should also take into account that there are design solutions that are much more suitable than others for improving women's risk perception.

2. Methodological Framework

The methodology applied in this paper is based on two research methods that are well-established and widely accepted in the literature. The first is the collection of data through a mixed Revealed Preference/Stated Preference (RP/SP) survey. The second is the estimation of discrete choice models that return accurate statistics on the study variables. The next two paragraphs briefly describe these methods and how they can be used to represent individuals' travel behaviors and their decision-making processes.

2.1. Survey Method

The interviewees were approached randomly in different points of the station, which could be either in the external square in front of the main entrance of the station, in the internal premises of the station, such as cafés, waiting rooms, ticket offices, etc., or near the platforms and the railway underpass. Respondents were subjected to a Paper and Pencil Interviewing (PAPI) process that included two sections, for a total survey duration of 10 min.

The first part of the survey consisted of an RP section aimed at obtaining data about the personal details of the interviewees and some information on their typical weekday trips. These are commonly known as revealed preferences, as they refer to choices made in real contexts that individuals experience every day. The information collected through a questionnaire included, but is not limited to: gender (female, male); age group (<26 y.o., 26–35 y.o., 36–45 y.o., 46–55 y.o., 56–65 y.o., >65 y.o.); family status (living alone, with parents and/or brothers and/or sisters, with colleagues, with partners and/or children); education level (none, elementary school, middle school, high school, university, other); professional status (employed, student, retired, unemployed, other); net monthly personal income (none, < EUR 900, EUR 900–1499, EUR 1500–2499, > EUR 2500); availability of private vehicles (car, motorcycle, etc.); and frequency of trips by car/motorcycle/train/public transport (0–2 trips per week, 3–5 trips per week, 6–7 trips per week). On this occasion, a question was also asked to find out the current opinion of the respondents about the overall level of safety and security perceived in the station. In particular, the interviewees had at their disposal the following predefined answers, designed on a 5-item Likert scale: (1) very unsafe, (2) a little unsafe, (3) neither unsafe nor safe, (4) pretty safe, and (5) very safe.

The second part of the survey consisted of an SP section aimed at understanding, through experimental designs, what the interviewees' choices are with respect to some proposed scenarios. These are commonly known as stated preferences, as they refer to choices made in hypothetical contexts. In fact, the interviewees had to compare a couple of figures representing some station design scenarios and then choose in which of the two they felt safer. This method allowed us to gather, in a very short time, a huge amount of information about the factors that have the greatest impact on individuals' perception of risks. This would not have been possible if the interviewers had to describe the characteristics of the scenarios in words or tables. It also avoided the fact that interviewers could in any way influence the interviewees' choices, and made it possible for the interviewees to carefully analyze hypothetical scenarios very familiar to the situations they experience every day. In fact, the figures were real photographs of some relevant places of the station, graphically processed for the addition or removal of some layers that represented the study variables (see Figures 1 and 2).

Figure 1. Example of treatments of the internal areas of the station.

Figure 2. Example of treatments of the external areas of the station.

It is well known in the literature that SP surveys allow one to obtain a greater number of observations than RP surveys for the same sample size, since each SP respondent is exposed to more choice scenarios than in RP survey (which considers only the actual context). They also allow one to take into consideration service quality attributes not present in the current scenario. However, this might generate some distortions due to possible discrepancies between the stated choice behavior and the actual one. This happens particularly due to unrealistic (i.e., unlikely) contexts, lack of relevant attributes for the decision maker in the scenarios, and fatigue of the interviewees by completing too many treatments. However, using some precautions, it is possible to avoid the above undesirable effects, and, in fact, several authors have already successfully used a similar approach [25–27].

Three different station environments were analyzed in the survey: the external square with the main entrance, the lobby with the waiting room, and the platforms. Instead, as regards the study variables, these included some prevention measures and devices (e.g., security personnel, surveillance cameras, tactile paths and signage, etc.), some boundary conditions (e.g., crowding, decorum, artificial lighting, etc.), and some characteristics of the built environment (e.g., greenery, intermodal infrastructure, commercial activities, etc.) that could directly or indirectly affect the perception of safety-related or security-related risks. In total, ten attributes of the station were analyzed, but not all of them appear in each of the three station environments, since some of them have no reason to be in certain contexts; see Table 1 for more details.

Table 1. The study variables considered depending on the station environment.

Environment	Attribute
External square with main entrance	• Greenery • Road crossings • Intermodal infrastructure • Security personnel • Surveillance cameras • Commercial activities
Internal lobby with the waiting room	• Security personnel • Surveillance cameras • Commercial activities • Artificial lighting • Crowding
Waiting areas near the platforms	• Security personnel • Surveillance cameras • Commercial activities • Crowding • Tactile path and signage • Decorum and maintenance

In this study, the attributes were introduced in scenarios with two levels of variation, i.e., they are dummy variables, where the value 1 indicates the presence of a design element (e.g., presence of "Commercial Activities", of "Surveillance Cameras", etc.), and 0 the absence; for other more qualitative variables, 1 means a high degree of occurrence of a study variable (e.g., high degree of "Crowding", of "Greenery", etc.), and 0 a low degree. The addition of further levels of variation, on the one hand, would have made it possible to verify the existence of nonlinear effects, on the other hand, it would have required the administration of an even greater number of treatments to the respondents, which would have drastically increased the length of each interview.

Examples of how these dummy variables were included in the scenarios are in the following tables and figures. Note how, for instance, in Scenario A of Figure 1, there is the presence of "Surveillance cameras", "Artificial lighting", and "Commercial activities", and the absence of "Security personnel" and "Crowding", and vice versa in Scenario B.

Attributes	Scenario A	Scenario B
Surveillance cameras	•	
Security personnel		•
Artificial lighting	•	
Commercial activities	•	
Crowding		•

Attributes	Scenario A	Scenario B
Surveillance cameras	•	
Security personnel	•	
Intermodal infrastructure		•
Commercial activities		•
Paths visibility		•
Greenery	•	

Given the large number of variables to be analyzed, albeit dummy (i.e., they vary only on 2 levels), it was preferrable to construct efficient stated preference experimental designs [28–30] for each of the station environments, in order to reduce the number of scenarios that need to be shown to a respondent. In fact, the full factorial design relating to the external areas of the station would have required a total number of $2^{6\times 2} = 4.096$ choice situations (treatments), given that there are 2 levels of variation for each of the 6 study variables considered in that station environment, and 2 alternatives of choice. A fractional factorial design was then created, selecting a subset of the choice situations of the full factorial design. In particular, the statistical efficient design was performed through NGENE software [31] with a D-optimality criterion, i.e., by maximizing the determinant of the Fisher information matrix. It was assumed that the utility functions of the two alternatives included only the dummy variables relating to the design elements of the station, and no possible variables of interaction with the socioeconomic attributes of the respondents; thus, accepting the compromise that a later inclusion of these additional variables in the utility function could have made the experimental design suboptimal. Furthermore, the use of such a fractional factorial design technique was possible, since some prior information about the parameters estimates was available from previous research. Finally, for each of the 3 station environments, the selection of 8 treatments was set in the software and divided into 2 blocks, each of which also respected the property of orthogonality. A total of 24 treatments were therefore selected.

2.2. Modeling Approach

In this research, first Multinomial Logit (MNL) models were estimated with NLOGIT software [32]. Indeed, it could be assumed that a respondent had well-defined preferences in each proposed pair of scenarios that make up a treatment. Indicating with U_i^j the utility function associated with scenario j by respondent i, it can be written:

$$U_i^j = \beta^j x_i^j + \varepsilon_i^j$$

where x_i^j are level-of-service attributes of the scenario j (and any interactions with the socioeconomic characteristics of the respondent i), β^j are fixed parameters associated with the attributes x_i^j, and ε_i^j are random residuals. Since two scenarios were associated with each treatment, the model compared the following two systematic utility functions for each respondent i:

$$\begin{aligned} V_i^1 = \; & \beta_{SC} SurveillanceCameras^1 + \beta_{SP} SecurityPersonnel^1 \\ & + \beta_{CA} CommercialActivities^1 + \beta_{RC} RoadCrossings^1 \\ & + \beta_S Signage^1 + \beta_G Greenery^1 + \beta_{IF} IntermodalInfrastructure^1 \\ & + \beta_{AL} ArtificialLighting^1 + \beta_C Crowding^1 \\ & + \beta_{DM} DecorumMaintenance^1 \end{aligned}$$

$$\begin{aligned} V_i^2 = \; & \beta_{SC} SurveillanceCameras^2 + \beta_{SP} SecurityPersonnel^2 \\ & + \beta_{CA} CommercialActivities^2 + \beta_{RC} RoadCrossings^2 \\ & + \beta_S Signage^2 + \beta_G Greenery^2 + \beta_{IF} IntermodalInfrastructure^2 \\ & + \beta_{AL} ArtificialLighting^2 + \beta_C Crowding^2 \\ & + \beta_{DM} DecorumMaintenance^2 \end{aligned}$$

where the attributes are dummy variables that are activated according to the scenario and the station environment, as described in the previous paragraph. The dependence of the systematic utility function on the characteristics of the *i*-th respondent occurs when any interactions with the socioeconomic attributes of the interviewee are taken into consideration in the specifications. Moreover, note that the parameters are generic over the two alternatives (i.e., scenario 1 and scenario 2), and that there are no alternative-specific constants, thus the alternatives are unlabeled.

Therefore, the observed choice Y_i of respondent i will be the scenario j if $U_i^j > U_i^k \; \forall k \neq j$. In MNL models the individual heterogeneity terms ε_i^j are assumed to be Independently and Identically Distributed (IID) and the choice probabilities P_i^j can be written in closed form as [33]:

$$P_i^j = \frac{\exp\left(\beta^j x_i^j\right)}{\sum_{j'} \exp\left(\beta^{j'} x_i^{j'}\right)} j = 0, \ldots, J$$

This approach made it possible to immediately point out which variables were statistically significant for the purposes of the choice of scenarios and to estimate their weights, i.e., which factors most affect the perceived safety and security by travelers. However, the IID assumptions are stringent and lead to the well-known Independence from Irrelevant Alternatives (IIA) implications.

Then, more advanced models were considered, even because one may argue that the parameters could be individual-specific. Under this assumption, the probabilities become:

$$P_i^j = \frac{\exp\left(\beta_i^j x_i^j\right)}{\sum_{j'} \exp\left(\beta_i^{j'} x_i^{j'}\right)} j = 0, \ldots, J$$

However, since the estimation of the parameters for every respondent would be possible only if a large number of observations are collected, and, given that the calculation of the choice probabilities involves a multidimensional integral which does not have closed form, it is more common to estimate the parameters β_i^j as random draws from a distribution. These kinds of models are known as Mixed Logit (ML). In this way, the expected value of a random parameter is estimated by the mean of the r draws on its distribution, and the choice probabilities P_i^r for every value of β^r can be calculated as:

$$P_i^r = \frac{\sum_j y_i^j \exp\left(\beta_i^r x_i^j\right)}{\sum_{j'} \exp(\beta_i^r x_i^{j'})} \; j = 0, \ldots, J$$

where y_i^j is a dummy variable equal to 1 if respondent i has chosen scenario j. Then, the individual parameters are obtained imposing the weighted average [33]:

$$\hat{\beta}_i = \frac{\sum_r \beta^r P_i^r}{\sum_r P_i^r}$$

Finally, since the survey method consisted of 4 treatments associated with the same respondent, in the ML models it was also assumed that the random parameters of a respondent remained the same in all their choice situations, i.e., a panel data version of the ML models were estimated.

3. Results and Discussion

In this section, the main findings of the survey are first highlighted and then the estimations of the behavioral models are reported and discussed. The former allowed us to qualitatively verify whether the risk perception varies according to some personal traits of the individual. The latter consented to quantitatively measure the weight of the study variables, both personal factors and characteristics of the build environment, which explain the choices of the travelers, i.e., their preferences and concerns regarding safety and security issues.

3.1. Survey Key Findings

The data described below refer to the RP questionnaires completed by 302 respondents, each of whom also participated in four treatments of the SP experiment for a total of 1208 observations. Respondents were approached randomly over the morning periods between 6.30 a.m. and 12.00 a.m. from the 9th to the 22nd of December, 2019 (excluding Sundays). The extension of the survey period allowed us to interview both commuters (i.e., workers and students who travel by train every day to a nearby town) and infrequent users who rarely use the station. Given the cross-sectional nature of the survey and the random sampling strategy adopted, there was no need to extend the survey to the second half of the day.

The sample consists of 48.7% of females and 68.5% of travelers under 36 years old. As can be seen in Table 2, 44.0% of the interviewees hold a university degree or higher and 38.7% are employed. About 76.5% declare a net monthly personal income of less than EUR 1500; this high percentage is explained by the fact that this category also includes those who have declared that they do not receive income (students and unemployed). Finally, 57.4% of the sample admits that, during the week, they mainly use PT services to travel. The remaining 42.6% of users generally use a car or a motorcycle, and this shows that there is also a large portion of occasional users in the sample.

Table 2. Sample distributions by socioeconomic characteristics and average ratings of the railway stations.

Individual Characteristics	Attributes	Distributions	Average Rating, $\overline{V}$
Gender	Female	48.7%	2.75
	Male	51.3%	3.08
Age	Under 36 years old.	68.5%	2.93
	Over 36 years old	31.5%	2.89
Education	High school or lower	56.0%	2.89
	University or higher	44.0%	2.95
Occupation	Employed	38.7%	2.81
	Student or Other	61.3%	2.99
Net monthly personal Income	Less than EUR 1500	76.5%	2.92
	More than EUR 1500	23.5%	2.93
Most frequently used transport mode	Private Transport (Car + Motorcycle)	42.6%	2.97
	Public Transport (Rail + Bus)	57.4%	2.91

Before allowing respondents to participate in the SP treatments, they were also asked to express an evaluation (V) on the perceived safety and security conditions in the railway station through a Likert scale, ranging from 1 to 5, with the following meaning: (1) very unsafe, (2) a little unsafe, (3) neither unsafe nor safe, (4) pretty safe, and (5) very safe. The average rating given by the overall sample of 302 interviewees is 2.92, which means that the station is perceived, on average, as neither unsafe nor safe, with a standard deviation of 1.01. Only 9.6% of respondents gave an extreme opinion (very unsafe or very safe). However, the graphs shown in Figure 3, which represent the frequencies of the ratings (1, 2, 3, 4, 5) by different socioeconomic characteristics and travel habits provide interesting evidence of gender differences in the perception of risks in a public transport environment. The only graph, and therefore the only personal factor, to show dissimilar distributions is that relating to the differentiation between females and males. The male distribution has a negative skew (i.e., the left tail is longer, and the mass of the distribution is concentrated on the right), while the female distribution has a positive skew (i.e., the right tail is longer, and the mass of the distribution is concentrated on the left). Furthermore, visually, it is possible to note that it is only in this case that there is a different mode value. The most frequent rating for males is 4 (i.e., the station is pretty safe), while for females it is 2 (i.e., the station is a little unsafe). The average rating of females (2.75) is almost half a point lower than the average rating given by males (3.08), and gender is the only factor in which a consistent deviation is noted (see Table 2).

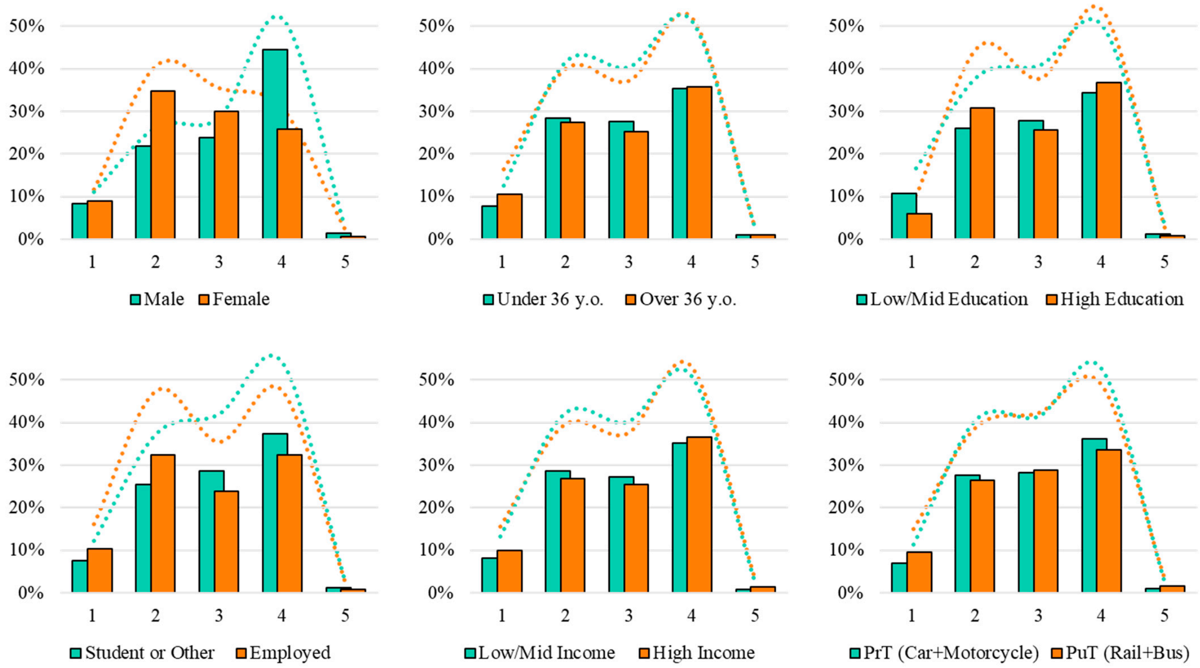

Figure 3. Distribution of ratings V by socioeconomic characteristics and travel habits.

3.2. Estimated Models

The results of the estimations of the MNL and ML models with NLOGIT software [32] are reported starting from Tables 3–5.

Table 3. Estimated models: overall sample with fixed parameters (MODEL 1) or random parameters (MODEL 2).

	MODEL 1 MNL		**MODEL 2** ML			
# observations	1208		1208			
Log likelihood function (constants)	−835.5		−835.5			
Log likelihood function (fitted)	−648.1		−571.6			
pseudo-R2	0.224		0.316			
Variable	**Coeff.**	**t-Ratio**	**Coeff.**	**t-Ratio**	**Std. Dev.**	**t-Ratio**
Surveillance cameras	0.46 ***	6.25	1.35 ***	3.50	1.65 **	2.49
Security personnel	0.89 ***	11.81	2.85 ***	3.69	3.49 ***	3.53
Commercial activities	0.08	1.21	0.34 *	1.81	1.16 **	1.97
Road crossings	1.12 ***	6.49	3.29 ***	3.06	2.06	1.55
Tactile paths and signage	−0.09	−0.72	−0.18	−0.36	0.87	0.36
Greenery	0.25 **	2.18	0.81 **	2.23	0.39	0.27
Intermodal infrastructure	0.45 ***	3.69	1.28 **	2.15	0.83	0.65
Artificial lighting	0.09	0.73	0.30	1.03	1.29 **	2.05
Crowding	0.34 ***	3.81	1.16 ***	2.62	0.33	0.36
Decorum and maintenance	1.11 ***	8.88	3.63 ***	3.42	4.76 ***	3.46

***, **, * refer to levels of significance of the estimated parameter respectively equal to 1%, 5%, 10%.

Table 4. Estimated models: split sample with fixed parameters (MODEL 3) and interactions (MODEL 4).

	MODEL 3 Female MNL			**MODEL 3 Male** MNL			**MODEL 4 Female** MNL			**MODEL 4 Male** MNL		
# observations	588			620			588			620		
Log likelihood function (constants)	−407.5			−425.3			−407.5			−425.3		
Log likelihood function (fitted)	−312.0			−328.8			−300.3			−326.4		
pseudo-R2	0.234			0.227			0.263			0.233		
Variable	**Coeff.**		**t-Ratio**	**Coeff.**		**t-Ratio**	**Coeff.**		**t-Ratio**	**Coeff.**		**t-Ratio**
Surveillance cameras	0.49	***	4.44	0.44	***	4.43	0.46	***	3.74	0.44	***	3.66
Security personnel	0.85	***	7.59	0.92	***	8.84	0.62	***	4.21	0.93	***	6.65
Commercial activities	0.05		0.44	0.09		0.90	−0.10		−0.82	0.08		0.68
Road crossings	1.22	***	4.53	1.03	***	4.40	1.00	***	3.07	0.73	**	2.39
Tactile paths and signage	−0.15		−0.72	−0.03		−0.17	−0.12		−0.56	- 0.02		−0.13
Greenery	0.00		−0.01	0.54	***	3.13	−0.04		−0.21	0.55	***	3.16
Intermodal infrastructure	0.51	***	3.00	0.36	**	2.01	0.27		1.28	0.24		1.13
Artificial lighting	0.14		0.83	0.03		0.18	0.14		0.84	0.03		0.18
Crowding	0.61	***	4.59	0.11		0.86	0.63	***	4.69	0.10		0.80
Decorum and maintenance	1.18	***	5.64	1.10	***	6.99	1.20	***	5.70	1.10	***	7.00
Interaction	**Coeff.**		**t-ratio**	**Coeff.**		**t-ratio**	**Coeff.**		**t-ratio**	**Coeff.**		**t-ratio**
Surveillance cameras * High income							0.49	*	1.80	−0.09		−0.44
Security personnel * Student							0.52	***	2.59	0.05		0.23
Comm. activities * Low freq. use of rail							0.54	**	2.26	0.05		0.24
Road crossings * High freq. use of car							0.55	*	1.70	0.55		1.53
Interm. Infrastr. * High freq. use of bus							0.80	**	2.40	0.52		1.31

***, **, * refer to levels of significance of the estimated parameter respectively equal to 1%, 5%, 10%.

First, a preliminary MNL model was estimated considering the overall analysis sample (1208 observations) and all study variables relating to the prevention measures or protection devices that characterize the different scenarios, except for socioeconomic variables. In this model, i.e., MODEL 1, it is first possible to notice how all the parameters of the variables are statistically significant, except for “commercial activities”, “tactile paths and signage”, and “artificial lighting”. The signs of the significant parameters are correct and consistent with what might have been expected: they are all positive, as their presence increases the value of the utility function of the scenario. In fact, the hypothesis is that the presence of these factors is preferred to their absence. Thus, for example, respondents should feel safer and therefore choose, all other variables being equal, a scenario in which there are “road crossings” clearly visible rather than one without. The assumption therefore seems to fail only for those variables such as “artificial lighting” (t-ratio equal to 0.73) and “tactile paths and signage” (−0.72), which do not result in any increase in the utility function, since the null hypothesis is accepted for them. However, it is more likely that their presence/absence has not been sufficiently perceived as not adequately reproduced through the proposed figures. As for “commercial activities”, its t-ratio leaves room for the variable to become significant in more advanced specifications. Finally, evaluating the absolute values of the parameters, from this first model, it would seem that the most important variables for travelers are “decorum and maintenance” (coefficient value equal to 1.11), “road crossings” (1.12), and “security personnel” (0.89), weighting twice or more than “surveillance cameras” (0.46), “intermodal infrastructure” (0.45), “crowding” (0.34), and “greenery” (0.25). MODEL 1, however, was estimated with the whole sample and without making any distinction between the categories of travelers.

For this reason, another preliminary model, in panel data version of an ML specification, has been developed. In MODEL 2, all study variables were maintained, but the parameters were assumed to be random (with a normal distribution). In this way, it is possible to explore the likelihood that differences exist in the preferences and perceptions of different categories of travelers, and, at the same time, consider any correlation of the choices made by the same individual. The goodness of fit of this more advanced statistical model (pseudo-R2 equal to 0.316) is far greater than the previous one (0.224). All the variables that were significant before are still significant, and, in addition, there is also "commercial activities". It is therefore evident that this factor in a public transport environment is perceived only by some individuals, and, therefore, the variable is significant only if the associated parameter is not fixed but, rather, random. However, note that not all distributions of standard deviations are statistically significant, and, therefore, not all parameters are justified in being random. Surely there is random taste variation for "surveillance cameras" (t-ratio equal to 2.49), "security personnel" (3.53), "commercial activities" (1.97), and "decorum and maintenance" (3.46), while, for the remaining variables, one could assume fixed parameters. This model also shows that the value of the standard deviation is always much greater than the value of the coefficient, so there is a very high variability in the preferences of the respondents.

Table 5. Estimated models: overall sample with fixed parameters and interactions (MODEL 5) or random parameters and heterogeneity in mean (MODEL 6).

	MODEL 5 MNL			**MODEL 6** ML					
# observations	1208			1208					
Log likelihood function (constants)	−835.5			−835.5					
Log likelihood function (fitted)	−632.1			−565.5					
pseudo-R2	0.243			0.323					
Variable	**Coeff.**		**t-ratio**	**Coeff.**		**t-ratio**	**Std. Dev.**		**t-ratio**
Surveillance cameras	0.44	***	5.84	0.94	***	5.00	0.84	**	2.22
Security personnel	0.83	***	9.92	1.79	***	5.61	2.25	***	5.84
Commercial activities	0.02		0.27	0.13		0.92	0.75	**	1.98
Road crossings	0.94	***	6.59	2.38	***	4.31	2.26	***	3.43
Greenery	0.52	***	3.08	1.31	***	3.36	0.42		0.78
Intermodal infrastructure	0.33	**	2.48	0.73	*	1.69	2.05	**	2.43
Crowding	0.10		0.86	0.21		0.59	1.49	***	2.70
Decorum and maintenance	1.12	***	8.97	2.48	***	5.36	2.08	***	2.94
Interaction	**Coeff.**		**t-Ratio**	**Coeff.**		**t-Ratio**	**Std. Dev.**		**t-Ratio**
Surveillance cameras * Female * High income	0.53	**	1.98						
Security personnel * Female * Student	0.34	**	2.00						
Commercial activities * Female * Low freq. use of rail	0.44	**	2.01						
Road crossings * Female * High freq. use of car	0.53	**	2.01						
Greenery * Female	−0.50	**	−2.16						
Intermodal infrastructure * Female * High freq. use of bus	0.78	***	2.62						
Crowding * Female	0.50	***	2.88						
Heterogeneity in mean [Random Parameter: Variable]	**Coeff.**		**t-ratio**	**Coeff.**		**t-ratio**	**Std. Dev.**		**t-ratio**
Surveillance cameras: Female * High income				0.92		1.45			
Security personnel: Female * Student				0.75		1.51			
Commercial activities: Female * Low freq. use of rail				0.72	*	1.74			
Road crossings: Female * High freq. use of car				0.96		1.29			
Greenery: Female				−1.28	**	−2.57			
Intermodal infrastructure: Female * High freq. use of bus				1.97	*	1.89			
Crowding: Female				1.00	*	1.90			

***, **, * refer to levels of significance of the estimated parameter respectively equal to 1%, 5%, 10%.

In Table 4, first attempts to explain this high variability are reported. In MODEL 3, the sample was split into females and males, with a respective number of 588 and 620, observations to check if differences due to gender do exist. These are MNL models specified, assuming that all the study variables are present in the utility functions of the scenarios. MODEL 3, estimated with only the treatments submitted to females, shows that the significant variables are "surveillance cameras", "security personnel", "road crossings", "intermodal infrastructure", "crowding", and "decorum and maintenance". On the other hand, considering only the treatments finalized by males, it appears that all the variables previously listed for females are statistically significant, except for "crowding", but, in addition, "greenery" is significant. These differences can be explained by the fact that, on the one hand, women generally perceive crowded places as more secure, as the presence of many other individuals probably decreases the likelihood of unpleasant events, such as harassment and assault, and, on the other, women are not as positively influenced as men by the presence of public greenery, hedges, or trees, since, for some female respondents, "greenery" could represent a threat (e.g., a hiding place for malicious people). Note that the parameters of the variables that are significant for both groups of individuals have similar values and proportions: "surveillance cameras" (0.49 vs. 0.44), "security personnel" (0.85 vs. 0.92), "road crossings" (1.22 vs. 1.03), "intermodal infrastructure" (0.51 vs. 0.36), and "decorum and maintenance" (1.18 vs. 1.10).

Afterwards, an attempt was made to better profile travelers on the basis of socioeconomic characteristics and travel habits. The results of this activity are shown with MODEL 4 in Table 4. The sample is still split between males and females. Compared to the previous model, interactions have also been included, which can be seen in the final rows of the table. In detail, it was found that some personal factors of the respondents are statistically significant for females and not for males. This is the case, for example, of "surveillance cameras", which are even more significant for women earning a high income. For this particular category of travelers, video surveillance cameras would have a total coefficient of 0.95, which is a value close to the parameters of the variables defined as most important in MODEL 1. Again, in line with other research [34], "security personnel" appears to be very important, mainly for young female students. Furthermore, "commercial activities" were found to be statistically significant only for occasional female travelers (i.e., those who reported that they rarely travel by train); in fact, it should be noted that the parameter of the variable "commercial activities", without the interaction, is no longer significant. For these individuals, bars, restaurants, newsagents, and shops could increase the perceived feeling of security, as commercial activities would induce the presence of additional people in the railway station, such as shopkeepers and customers. As regards the "road crossings" variable, it can be said that the problem of pedestrian crossings is even more relevant for users who frequently reach the station by car. A possible explanation is that parking lots are rarely in front of the station entrance and can be quite far away, which forces travelers to take a final walk to reach the station. Moreover, as might be expected, the enhancement of "intermodal infrastructure" near the railway station is especially appreciated by those females who frequently use PT bus services. Finally, it can be seen, considering the pseudo-R2s, how the inclusion of such interactions results in slightly more robust models than the previous MODEL 3s.

On the basis of this evidence, further models were estimated to verify the existence of gender differences without distinguishing a priori between treatments carried out by females and males. In detail, MODEL 5 is an MNL specification estimated with the overall sample, in which the study variables that never turned out significant in the previous estimates have been eliminated, the significant interactions have been maintained, and two interactions have been added for "greenery" and "crowding", since they were perceived in an opposing way by the two genders. As can be seen in Table 5, this model presents all the variables with quite high t-ratios, except for "commercial activities" which, as already mentioned, are significant only for occasional female users, and "crowding", which is significant just for females. The only coefficient to be negative is that of the "greenery * female" interaction, which, however, is comparable in absolute value to the "greenery" coefficient. In fact, the absolute values are very similar, and the decrease of the interaction variable annuls the increase made to the utility function by the original variable.

As occurred in the transition from MODEL 1 to MODEL 2, the parameters of the study variables were made random in MODEL 6, again assuming a normal distribution. In addition, an effort was made to explain, at least in part, the unobserved heterogeneity by allowing the mean of the random parameter to be a function of explanatory variables. For the latter, the gender interaction variables found to be statistically significant in MODEL 5 were used. MODEL 6 highlights, on the one hand, that almost all random parameters have a significant standard deviation, and, therefore, that there is still some unobserved heterogeneity for most of them. On the other, it shows also that the "female" explanatory variable seems to perfectly explain the random taste variation of travelers with respect to "greenery". As regards "commercial activities" and "crowding", it should be noted that the heterogeneity in the means replace the means themselves of the random parameters. For the "intermodal infrastructure" variable, both the mean of the random parameter, the explanatory variable and the randomly distributed term that captures unobserved heterogeneity, are significant. Finally, the explanatory variables used for "surveillance cameras", "security personnel", and "road crossings" present t-ratios that recommend accepting the null hypothesis. Thus, it can be concluded that gender differences relating to how travelers feel safe and secure in a railway station are mainly to be identified in the different ways in which some characteristics of the built environments are perceived, such as the presence or absence of "commercials activities", "greenery", "intermodal infrastructure", and "crowding". Moreover, if it is true that "decorum and maintenance" and "road crossings" remain the variables with the highest coefficient values, it should nevertheless be noted that, for example, the presence of "intermodal infrastructure" becomes the most important variable for the category of female travelers that regularly ride PT services. This leaves room for broad considerations on the fact that travelers do not all have the same needs, and that, in terms of perceived safety and security, some infrastructural, organizational, or technological interventions may be more preferred by some categories of users than others.

4. Conclusions

This research emphasized the estimation of discrete choice models to identify which factors most affect travelers' safety and security perceptions in a railway station, and used Mixed-Logit models to verify the existence of heterogeneity in travelers' choice behavior due to gender.

The methodology first involved data collection through a mixed RP/SP survey. The administration of the experiment by means of real photographs of some relevant places of the station (adequately preprocessed to define the study variables) proved to be a highly effective technique. This is because, on the one hand, the respondents evaluated scenarios that were very familiar to their daily experience, and, on the other, they made it possible to quickly collect what leaps faster to the eye, and, therefore, their most instinctive perceptions and impressions. The survey campaign made it possible to collect the responses of 302 travelers in relation to 2416 scenarios, which, having been administered in pairs, allowed the estimation of the models on a total of 1208 stated preference observations.

As anticipated by the descriptive statistics of the RP questionnaires, it emerged that women perceive the railway station as less safe and secure than men, highlighting the existence of a gender inequality that can seriously affect the mobility of female travelers. With the SP experimental designs, it was possible not to limit the analysis to the investigation of current motivations, but to generalize the results by identifying the factors that best explain the gender differences through the administration of hypothetical scenarios. The most striking difference is found in the perception that women have of crowding and the presence of commercial activities (probably related to the former). The choices made by the female respondents show that it is likely that women mostly feel more secure in the presence of many other people, since it is probably perceived that, in such situations, the likelihood of unpleasant events, such as harassment and assault, decreases. On the other hand, women are not as positively influenced as men by the presence of hedges and trees, since they could be a great hiding place for malicious people. The presence of infrastructures for intermodal transshipments very close to the station entrance are particularly appreciated by the category of female travelers who often use the bus to reach the station. Finally, in some models, the presence of surveillance cameras and security personnel were also relevant for women with high personal income and for young female students, respectively.

In conclusion, if all travelers, without distinction of gender are considered, it emerges that the most relevant measures to increase perceived safety and security are improvements in the level of decorum, the visibility of road crossings, and the presence of security personnel. However, if the aim is to reduce the feeling of insecurity of the demand segments that perceives the station to be more insecure on average (e.g., female), then the focus should also be on locating intermodal infrastructures adjacent to the station entrance, and avoiding too widespread an insertion of public greenery, as it could limit the visibility of paths and areas near the station.

This paper ranks in the literature among those which argue that gender is among the most conditioning of personal factors; besides providing an original contribution by treating a medium-sized Italian railway station as a case study. Moreover, it points out that women have different reactions than men to preventive measures and protective devices implemented. In conclusion, in order to reduce the gender gap in feeling safe and secure in a transit environment, such as a train station, transport planners and operators should strive to implement those aforementioned interventions that most effectively and efficiently succeed in this intent. Otherwise, by failing to consider the distinctive personal attitudes and travel behaviors of different traveler profiles equally, they might contribute to the creation of gender gaps in the mobility of people.

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