Influence of station characteristics, urban surroundings and perceived safety on satisfaction and public transport ridership

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Short summary

Public transport (PT) is essential to fulfill travel needs in urban areas. Predictors of PT ridership and satisfaction provide a good understanding of how new users can be attracted and existing users can be retained. Among these predictors, perceived safety and built environment (BE) attributes of stations and their surroundings still require further research. Using data from a tailor-made survey on train trips in East Denmark (1,004 respondents), we investigate the relationship between perceived safety, satisfaction and PT ridership and highlight the influence of BE attributes. Based on a structural equation model, we find a significant relationship between (i) perceived safety and satisfaction with trip-ends, and (ii) satisfaction with trip-ends and overall trip satisfaction. Lighting, maintenance and wayfinding are some of the essential attributes of stations, and their surroundings should not have isolated areas. No significant effect was found for trip satisfaction on PT ridership, but further research will consider this relationship.
Keywords: Public transport; Perceived safety; Satisfaction; Station design; Structural equation modelling

1 Introduction

Public transport (PT) is an important travel mode in urban areas, serving a heterogeneous set of users and contributing to more sustainable transport and social equity in cities. While attracting new PT users requires a good understanding of predictors of PT ridership, ensuring existing users' satisfaction is crucial to retain their ridership (van Lierop et al., 2018). Both PT ridership and satisfaction are linked to the built environment (BE) attributes, including those of station environments and their surroundings (Iseki et al., 2007; Susilo & Cats, 2014; Taylor & Fink, 2013). In addition, perceived safety is a crucial factor in predicting both ridership and satisfaction with the overall trip and can be enhanced by improving the stations and their surroundings as well (Ingvardson & Nielsen, 2021; Iseki et al., 2007; Susilo & Cats, 2014). However, further research is necessary to investigate which of these BE attributes have the highest importance for satisfaction and ridership.

Satisfaction with PT is influenced by a high number of factors, among which on-board cleanliness, comfort and staff behaviour are the most common ones according to a recent review (van Lierop et al., 2018). While these are trip attributes, station attributes such as wayfinding (Nielsen et al., 2021), real-time information (Chowdhury & Ceder, 2013), maintenance and cleanliness (Eboli et al., 2018) also improve users' experience. There are, however, few studies on PT satisfaction which incorporate urban characteristics.

Perceived safety is one of the most crucial needs which has to be fulfilled for a PT trip to take place, as otherwise, one might have to alter the time or mode of the trip, or cancel the trip completely (Loukaitou-Sideris et al., 2009; Lubitow et al., 2017). Focusing on lighting, maintenance, real-time information and staff presence can help achieve safe station environments which can encourage PT users (Cozens et al., 2003; Rahaman et al., 2016). That said, urban design around stations is at least as important as at the station. Providing trees (Basu et al., 2022), good lighting and human activity (Iseki et al., 2007) enhance perceived safety around stations while the presence of isolated areas or unused parking lots negatively affect it (Iseki et al., 2007).

This study analyzes the influence of station characteristics, urban surroundings and perceived safety on satisfaction as well as PT ridership, focusing on train travel in East Denmark. Using a tailor-made online survey incorporating a detailed list of built environment attributes, we estimate a comprehensive structural equation model (SEM). First, we examine which attributes of train stations and their surroundings improve perceived safety and satisfaction. We do this separately at the home and activity ends of the trip to consider explicitly potential differences in user perceptions. Second, we investigate whether overall trip satisfaction increases with higher levels of satisfaction with individual attributes at both trip ends. Lastly, we explore the relationship between trip satisfaction and PT ridership. The SEM framework allows for analysing these relationships in detail through both the direct and indirect effects. Our final data set comprises 1,004 train trips made by a large sample of PT users in East Denmark in June-July 2022.

2 Methodology

Survey design and data collection

We designed an online survey in Danish, with 35-40 questions in three parts: (i) travel patterns and preferences towards the attributes of stations and their surroundings, (ii) details of respondents' latest train trip, and (iii) background questions.

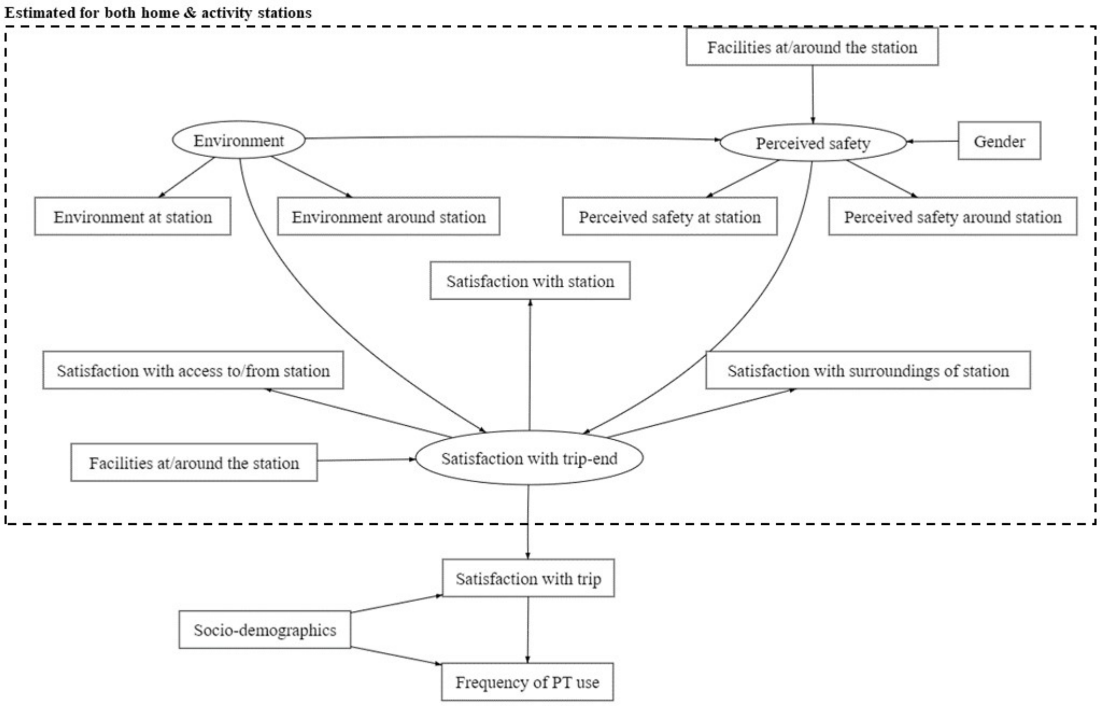
In the first part, we included station facilities (e.g. escalators, information screens, wayfinding), station surroundings (e.g. human activity, large parking lots), environment at/around stations (noise, air quality, lighting, maintenance, cleanliness), and access paths to stations (e.g. tunnels, pedestrian streets). We measured the importance of the selected attributes on a 5-point Likert scale (1: Very unimportant, 5: Very important). In the second part, we collected which of these attributes were present on the specific trip, and measured respondents' perceived safety level. To provide a concrete scenario, we asked the respondents to rank how safe they would feel after dark at/around their stations on a 5-point Likert scale. We also measured satisfaction with: (a) station, (b) station surroundings, (c) access to/from the station, and (d) the entire trip, all measured on a 5-point Likert scale. Items (a) to (c) were repeated for start and end stations. In the third part, we asked about gender, age, education, and access to transport resources.

We distributed the online survey through a panel of PT users from the Danish consumer watchdog for public transport (Passenger Pulse). We targeted PT users over 18-years old who reside in East Denmark, an area which includes the city of Copenhagen and has more than 2 million residents. Collecting data in June-July 2022, we reached 1,314 complete responses in the final data set.

Analysis method

Figure 1 shows our framework which covers the relationship between perceived safety, satisfaction variables and frequency of PT use, while also exploring the effects of station characteristics and urban surroundings. Socio-demographic variables are included to account for different user groups' needs and experiences. We followed a structural equation modelling approach, as it allows for simultaneous consideration of the dependent variables in a consistent manner. As we expected a difference in individuals' preferences at home and activity ends of the trip, we created latent variables and estimated models for both trip ends in the same SEM model.

Figure 1: Structural equation modelling framework where circles represent latent variables.



In the SEM model, we introduced variables in 5-point scales as continuous variables in the model, and employed dummy variables for the yes/no questions or categorical variables (e.g. age, education).

In the measurement part of the SEM model, we applied confirmatory factor analysis (CFA) to create latent variables from items which were measured both at and around the stations. The five environment variables and perceived safety underwent this procedure separately at home and activity ends. We also loaded the three satisfaction items (i.e. satisfaction with access conditions, satisfaction with station surroundings, satisfaction with the station) into a single latent variable at each trip end.

In the structural part, we estimated models explaining these latent variables at both trip ends as well as satisfaction with the trip and frequency of PT use to test several hypotheses. First, we expected that maintenance and lighting, along with BE attributes and gender, significantly affected perceived safety at both trip ends. Second, we expected a positive significant relationship between perceived safety and satisfaction with trip ends, in addition to the significant effect of attributes such as wayfinding and crowdedness. Third, we hypothesised that satisfaction with trip ends would significantly contribute to the satisfaction with the overall trip and that there would be significant differences based on socio-demographics. Lastly, we expected a significant positive effect of satisfaction with the overall trip on frequency of PT use, in addition to socio-demographics.

3 Sample statistics

To test whether respondents have different preferences at home and activity ends of their trips, we converted start & end stations into home-end & activity-end stations depending on whether the trip started or ended at home. After removing trips with missing values, our modelling data set includes 1,004 trips. These 1,004 trips cover 180 stations out of the 297 in the region, and the largest transport hubs are represented. The remainder of the stations are mostly smaller local train stations with few daily users.

Table 1 describes the full sample (N= 1,314), and the sample used in the SEM model (N=1,004). In addition, we show the sample of PT users in the Danish National Travel Survey (Transportvaneundersøgelsen) between 2018-2022 for comparison, as this survey is representative for Denmark (Christiansen & Skougaard, 2015). In all three samples, women are slightly overrepresented. Given their low percentage, we merged "nonbinary" and "other" categories with women in the rest of the analysis. Both of our samples stand out with their age distribution from the TU sample, with a higher share of individuals over 50-years-old. This is a result of the age bias in the Passenger

Pulse panel, which has an average age of 61. Furthermore, our sample is more educated and has higher income levels than the TU sample. In terms of access to transport resources, the samples resemble each other.

Table 1: Sample description, compared to the description of PT users in the Danish NTS

Variable	Full sample	SEM sample	Danish NTS PT users
Gender			
Female	55.1%	54.7%	53.5%
Male	43.8%	45.0%	46.5%
Nonbinary	0.1%	0.1%	-
Prefer not to say	1.1%	-	-
Other	0.2%	0.2%	-
Age			
18-29	2.4%	2.6%	39.7%
30-39	5.0%	4.8%	19.9%
40-49	9.8%	10.0%	12.5%
50-59	21.9%	21.6%	12.2%
60-69	29.3%	29.6%	7.9%
70-79	26.7%	26.7%	5.9%
$>$80	4.9%	4.8%	1.9%
Education			
Primary school	2.7%	3.2%	14.7%
High school	4.6%	4.8%	17.6%
Vocational	13.4%	13.8%	9.8%
Short-term higher education (1.5-2 years)	7.2%	6.8%	4.6%
Medium-tem higher education (2-5 years)	36.2%	36.6%	27.1%
Long-term higher education (5+ years)	35.8%	34.9%	26.2%
Income			
0-99.999 DKK	1.9%	1.8%	9.2%
100.000-199.999 DKK	7.3%	7.5%	9.8%
200.000-299.999 DKK	16.8%	17.6%	9.3%
300.000-399.999 DKK	18.3%	18.9%	12.9%
400.000-499.999 DKK	15.4%	15.4%	8.9%
More than 500.000 DKK	25.0%	25.4%	11.7%
NA	15.2%	13.3%	38.2%
Car availability			
Yes	55.7%	56.0%	47.7%
No	44.3%	44.0%	52.3%
Bicycle availability			
Yes	73.8%	84.8%	76.4%
No	26.2%	15.2%	23.6%
Driving licence			
Yes	84.3%	74.6%	70.8%
No	15.7%	25.4%	29.2%
No. of obs	1314	1004	1850

We describe the frequency of using different transport modes in table 2. 55.6% of the SEM sample travels at least 3-4 times a week with PT. Similarly, more than half of the respondents walk or cycle frequently, while the share of car drivers and passengers are quite low. E-scooters, shared bicycles and shared cars are almost never used.

Table 2: Frequency of travelling with different modes in the SEM sample (N=1004)

Transport mode	**Never**	**Less than once a month**	**1-3 times a month**	**1-2 times a week**	**3-4 times a week**	**5 times or more a week**
Public transport	0.5%	4.6%	18.3%	21.0%	24.6%	31.0%
Car driver	45.6%	9.7%	10.0%	16.0%	10.6%	8.2%
Car passenger	17.2%	33.0%	26.1%	18.2%	3.8%	1.7%
Walking	2.3%	2.4%	4.6%	9.7%	14.6%	66.4%
Own bicycle	22.3%	9.5%	7.7%	9.1%	15.4%	36.1%
E-scooter	98.0%	1.6%	0.3%	-	-	0.1%
Shared bicycle	98.3%	1.4%	0.2%	0.1%	-	-
Shared car	93.8%	3.9%	1.2%	0.8%	0.2%	0.1%

Table 3 describes the environment at and around stations at both trip ends. Noise levels are perceived higher at the activity end, which is expected given that stations with high activity levels are mostly located in the centre of Copenhagen while quieter suburbs are represented more in the home stations. Air quality shows a similar pattern with a higher share of respondents reporting bad conditions at activity ends. At least 40 % of respondents state good lighting conditions in all cases. Maintenance and cleanliness distributions are similar in all four cases, achieving high rankings from approximately 30 % of the sample.

Table 3: Description of environment variables in the SEM sample (N=1,004) ([a] The noise variable is reverse coded where 1: very quiet, 5: very loud. For all other variables, 1: very bad, 5: very good.)

Environment	**1**	**2**	**3**	**4**	**5**	**Average**	**Std.Dev**
At home station							
Noise[a]	8.6%	33.8%	45.4%	11.2%	1.1%	2.62	0.83
Air quality	1.6%	7.5%	43.8%	34.3%	12.9%	3.49	0.87
Lighting	1.5%	10.2%	38.8%	42.4%	7.1%	3.43	0.82
Maintenance	5.5%	23.4%	37.3%	30.0%	3.9%	3.03	0.95
Cleanliness	4.2%	24.4%	39.8%	27.3%	4.3%	3.03	0.92
Around home station							
Noise[a]	6.3%	32.5%	40.6%	18.6%	2.0%	2.78	0.89
Air quality	1.6%	10.6%	44.5%	32.6%	10.8%	3.40	0.87
Lighting	1.2%	11.6%	41.3%	41.6%	4.3%	3.36	0.79
Maintenance	3.3%	19.5%	44.7%	29.7%	2.8%	3.09	0.85
Cleanliness	3.5%	22.2%	45.7%	25.6%	3.0%	3.02	0.86
At activity station							
Noise[a]	5.1%	17.3%	44.5%	27.2%	5.9%	3.11	0.93
Air quality	3.6%	19.8%	46.2%	25.2%	5.2%	3.09	0.89
Lighting	1.3%	10.8%	42.8%	40.4%	4.7%	3.36	0.79
Maintenance	4.9%	15.4%	44.5%	30.5%	4.7%	3.15	0.91
Cleanliness	5.7%	19.2%	42.7%	28.8%	3.6%	3.05	0.92
Around activity station							
Noise[a]	3.8%	14.4%	38.8%	35.9%	7.2%	3.28	0.93
Air quality	3.5%	22.9%	48.2%	21.1%	4.3%	3.00	0.87
Lighting	0.9%	9.7%	46.8%	38.8%	3.8%	3.35	0.74
Maintenance	3.3%	15.5%	50.0%	27.3%	3.9%	3.13	0.84
Cleanliness	5.2%	21.9%	46.1%	24.2%	2.6%	2.97	0.88

The overall perceived safety levels at and around stations are high, as almost 50 % of the sample rank perceived safety 4 or higher (Figure 4). The distribution of scores at and around each trip end are quite similar.

Table 4: Description of perceived safety in the SEM sample (N=1004)

Perceived safety	**1 - Very unsafe**	**2**	**3**	**4**	**5 - Very safe**	**Average**	**Std. dev.**
Around home station	4.6%	13.7%	24.9%	43.2%	13.7%	3.48	1.04
At home station	5.0%	13.8%	26.0%	42.4%	12.9%	3.44	1.04
Around activity station	2.7%	12.1%	35.9%	39.7%	9.7%	3.42	0.92
At activity station	2.9%	12.8%	33.9%	41.5%	9.0%	3.41	0.92

As table 5 shows, the sample has quite high satisfaction levels, the highest being trip satisfaction with 74.4% respondents stating that they are satisfied or very satisfied, leading to an average score of 3.85/5.

Table 5: Description of satisfaction variables in the SEM sample (N=1004)

Satisfaction with:	**1 - Very unsatisfied**	**2**	**3**	**4**	**5 -Very satisfied**	**Average**	**Std. dev.**
Access to/from the home station	2.8%	7.6%	18.7%	49.1%	21.8%	3.80	0.96
Surroundings of home station	3.8%	12.3%	27.0%	42.3%	14.6%	3.52	1.01
Home station	3.4%	8.3%	35.0%	41.7%	11.7%	3.63	0.96
Access to/from the activity station	2.7%	11.3%	21.4%	49.5%	15.1%	3.76	0.91
Surroundings of activity station	2.1%	7.1%	22.2%	50.2%	18.4%	3.50	0.92
Activity station	2.5%	8.8%	25.7%	51.5%	11.6%	3.61	0.89
Trip	3.3%	3.7%	18.6%	53.8%	20.6%	3.85	0.90

Lastly, tables 6 and 7 describe the facilities at/around stations from the SEM model. As the activity stations are at more central locations, they have a lower share of large parking lots, closed facades and isolated areas, while the share of urban life is also higher. In most cases (86%), respondents did not experience problems seeing information screens at stations. A similar percentage of respondents report good wayfinding at stations while crowdedness appears to be a bigger problem at the activity-end.

Table 6: Description of attributes at and around home/activity stations in the SEM sample (N=1004)

	Home-end		**Activity-end**	
Attribute	**No**	**Yes**	**No**	**Yes**
Shops around	55.8%	44.2%	50.8%	49.2%
Urban life around	58.6%	41.4%	44.0%	56.0%
Large parking lots around	67.3%	32.7%	81.7%	18.3%
Closed facades around	81.2%	18.8%	84.2%	15.8%
Isolated areas around	76.7%	23.3%	85.4%	14.6%
Trees around	55.5%	44.5%	70.7%	29.3%
Problem seeing information screens	86.5%	13.6%	86.8%	13.3%
Respondent used elevator	83.6%	16.4%	84.9%	15.1%
Respondent used escalator	89.2%	10.8%	78.1%	21.9%
Respondent used stairs	31.7%	68.3%	35.0%	65.0%
Access via pedestrian street	64.2%	35.8%	57.4%	42.6%
Access via tunnel	72.2%	27.8%	74.2%	25.8%
Access via bridge	86.5%	13.6%	87.3%	12.8%
Access via bike path	70.5%	29.5%	78.9%	21.1%

Table 7: Description of attributes at home/activity stations (N=1004) ([b]: The crowdedness variable is reverse coded where 1: very crowded, 5: not crowded at all)

Attribute	1	2	3	4	5
Home station					
Wayfinding	1.0%	3.4%	6.3%	27.0%	62.4%
Crowdedness[b]	4.8%	26.6%	24.4%	32.6%	11.7%
Activity station					
Wayfinding	0.9%	5.6%	7.2%	31.0%	55.4%
Crowdedness[b]	12.5%	29.4%	24.6%	24.0%	9.6%

4 Results and discussion

To test our hypotheses, we estimated a SEM model. When designing the model, we looked at the correlation between the variables described so far, and found that most of the attributes measured both at and around the station were highly correlated. For example, two variables measuring perceived safety at/around the home stations had a statistically significant correlation coefficient of 0.86. This was also the case for the three satisfaction variables (at, around, access) and environment variables. This informed the decision to create latent variables. Maintenance and cleanliness variables were also highly correlated in all cases (>0.70). Therefore, we defined residual covariances between these variables in the SEM model. The fit indices show acceptable model fit with RMSEA and SRMR both below 0.08. However, CFI is slightly below the required level of 0.90 (Table 8).

Table 8: Goodness-of-fit measures of the SEM model

Num of. obs	χ^2	DoF	P-value	Comparative Fit Index	RMSEA	SRMR
1004	4901.87	1712	0.00	0.862	0.043	0.064

We present the measurement part of our SEM model in table 9, and the structural part in tables 10 to 12. All indicators in the CFA have loaded into their corresponding latent variables with acceptable loading, and the Cronbach's alpha values were all above 0.70 thus suggesting good internal consistency (Miller, 1995). We introduced these variables as explanatory, and in some cases, also dependent variables in the structural part.

Table 9: Measurement model (N=1,004)

Latent variable (Cronbach's alpha)	Indicator	Std. Coef.	Std.Err	P-value	Sig.
Satisfaction_home (0.84)	Satisfaction with the home station		1	0.83	
	Satisfaction with access to/from the home station	0.72	0.04	0.00	***
	Satisfaction with surroundings of home station	0.75	0.04	0.00	***
Noise_home (0.80)	Noise at home		1.00	0.64	
	Noise around home	0.87	0.06	0.00	***
Air_home (0.85)	Air quality at home		1.00	0.74	
	Air quality around home	0.88	0.04	0.00	***
Lighthing_home (0.82)	Lighting at home		1.00	0.69	
	Lighting around home	0.81	0.04	0.00	***
Maintenance_home (0.80)	Maintenance at home		1.00	0.79	
	Maintenance around home	0.79	0.03	0.00	***
Cleanliness_home (0.83)	Cleanliness at home		1.00	0.82	
	Cleanliness around home	0.81	0.03	0.00	***
Safety_home (0.93)	Perceived safety at home station		1.00	0.99	
	Perceived safety around home station	0.89	0.03	0.00	***
Satisfaction_activity (0.83)	Satisfaction with the activity station		1.00	0.75	
	Satisfaction with access to/from the activity station	0.67	0.04	0.00	***
	Satisfaction with surroundings of activity station	0.67	0.04	0.00	***
Noise_activity (0.84)	Noise at activity		1.00	0.76	
	Noise around activity	0.88	0.04	0.00	***
Air_activity (0.86)	Air quality at activity		1.00	0.77	
	Air quality around activity	0.87	0.03	0.00	***
Lighthing_activity (0.78)	Lighting at activity		1.00	0.65	
	Lighting around activity	0.77	0.04	0.00	***
Maintenance_activity (0.83)	Maintenance at activity		1.00	0.76	
	Maintenance around activity	0.83	0.03	0.00	***
Cleanliness_activity (0.84)	Cleanliness at activity		1.00	0.78	
	Cleanliness around activity	0.86	0.03	0.00	***
Safety_activity (0.92)	Perceived safety at activity station		1.00	0.85	
	Perceived safety around activity station	0.91	0.04	0.00	***

***: p <=0.001, **: 0.001<p <=0.01, *: 0.01<p <=0.05 , . : 0.05 <p <= 0.1

The models explaining the latent perceived safety variables at home and activity ends identify isolated areas around stations, lighting conditions and gender as common significant predictors in both cases (Table 10). While increasing levels of isolation reduce perceived safety, good lighting conditions improve the experience. Men feel significantly safer than non-male respondents. At home-end, urban life and trees also have positive and significant parameter estimates.

Table 10: Structural model - perceived safety (N=1,004)

Dependent variable	Explanatory variable	Std. Coef.	Std.Err	P-value	Sig.
Safety_home	Shops around home station	0.03	0.06	0.38	
	Urban life around home station	0.07	0.06	0.04	*
	Large parking lots around home station	-0.03	0.06	0.29	
	Closed facades around home station	-0.03	0.07	0.37	
	Isolated areas around home station	-0.11	0.07	0.00	***
	Trees around home station	0.06	0.06	0.05	.
	Lighting_home	0.46	0.07	0.00	***
	Maintenance_home	0.05	0.06	0.31	
	Male (Ref: Female and other)	0.14	0.06	0.00	***
Safety_activity	Shops around activity station	0.04	0.05	0.20	
	Urban life around activity station	0.03	0.06	0.32	
	Large parking lots around activity station	-0.04	0.07	0.26	
	Closed facades around activity station	-0.01	0.07	0.76	
	Isolated areas around activity station	-0.13	0.08	0.00	***
	Trees around activity station	0.02	0.06	0.49	
	Lighting_activity	0.30	0.09	0.00	***
	Maintenance_activity	0.11	0.08	0.13	
	Male (Ref: Female and other)	0.13	0.05	0.00	***

***: p <=0.001, **: 0.001<p <=0.01, *: 0.01<p <=0.05 , . : 0.05 <p <= 0.1

For satisfaction with trip ends, maintenance, perceived safety, wayfinding and problems with seeing screens are significant at both ends (Table 11). Except for problems with seeing information screens, these common predictors significantly increase satisfaction with trip ends. Satisfaction with the home station significantly reduces if the respondent has used escalators or stairs. This could imply a dispreference towards level changes or an unpleasant experience due to dirty elevators or long stairs.

Table 11: Structural model cont'd - satisfaction with stations (N=1,004)

Dependent variable	**Explanatory variable**	**Std. Coef.**	**Std.Err**	**P-value**	**Sig.**
Satisfaction_home	Noise_home	0.00	0.07	0.94	
	Air_home	0.01	0.06	0.93	
	Lighthing_home	0.02	0.07	0.71	
	Maintenance_home	0.53	0.09	0.00	***
	Cleanliness_home	0.04	0.07	0.53	
	Safety_home	0.24	0.03	0.00	***
	Access via pedestrian street	0.08	0.05	0.01	**
	Access via tunnel	0.02	0.05	0.54	
	Access via bridge	0.00	0.07	0.95	
	Access via bike path	0.11	0.05	0.00	***
	Wayfinding_home	0.15	0.03	0.00	***
	Problems seeing information screens	-0.11	0.06	0.00	***
	Used escalator	-0.06	0.07	0.04	*
	Used stairs	-0.08	0.06	0.01	*
	Used elevator	0.02	0.07	0.52	
	Crowedness	-0.02	0.02	0.43	
Satisfaction_activity	Noise_activity	-0.07	0.07	0.34	
	Air_activity	0.03	0.08	0.67	
	Lighthing_activity	0.06	0.09	0.40	
	Maintenance_activity	0.54	0.11	0.00	***
	Cleanliness_activity	0.03	0.09	0.73	
	Safety_activity	0.14	0.03	0.00	***
	Access via pedestrian street	0.13	0.05	0.00	***
	Access via tunnel	0.02	0.05	0.52	
	Access via bridge	0.03	0.06	0.30	
	Access via bike path	0.05	0.06	0.13	
	Wayfinding_home	0.14	0.02	0.00	***
	Problems seeing information screens	-0.09	0.06	0.00	***
	Used escalator	0.06	0.06	0.08	.
	Used stairs	-0.01	0.06	0.82	
	Used elevator	0.03	0.07	0.43	
	Crowedness	0.04	0.02	0.16	

***: p <=0.001, **: 0.001<p <=0.01, *: 0.01<p <=0.05 , . : 0.05 <p <= 0.1

As table 12 shows, satisfaction with the station conditions in both trip ends has a significant positive relationship with trip satisfaction. There is also a slight gender effect where men are less satisfied than non-male respondents. Respondents without a car are also slightly more likely to be satisfied with their trip. Education, which was added as a proxy for income, does not show a strong effect. Lastly, all age categories are less satisfied than respondents over 70-years-old, however only one of these categories is significant.
Unlike our expectation, satisfaction with the trip does not significantly influence frequency of PT use. However, age and not owning a car have strong effects.

Table 12: Structural model cont'd - trip satisfaction and frequency of PT use (N=1,004)

Dependent variable	Explanatory variable	Std. Coef.	Std.Err	P-value	Sig.
Satisfaction with the trip	Satisfaction_home	0.28	0.05	0.00	***
	Satisfaction_activity	0.32	0.05	0.00	***
	Male (Ref: Female and other)	-0.05	0.05	0.06	.
	No cars (Ref: Car owner)	0.05	0.05	0.07	.
	Education - Primary school (Ref: 2+ year higher ed.)	-0.03	0.14	0.34	
	Education - Highschool (Ref: 2+ year higher ed.)	0.05	0.12	0.11	
	Education - Vocational (Ref: 2+ year higher ed.)	0.07	0.07	0.01	*
	Education - Shrt higher education (Ref: 2+ year higher ed.)	-0.02	0.10	0.58	
	Age - 18-29 (Ref: 70+)	-0.06	0.16	0.04	*
	Age - 30-39 (Ref: 70+)	-0.06	0.12	0.06	.
	Age - 40-49 (Ref: 70+)	-0.05	0.09	0.12	
	Age - 50-59 (Ref: 70+)	-0.06	0.07	0.08	.
	Age - 60-69 (Ref: 70+)	-0.08	0.06	0.02	*
Frequency of PT use	Satisfaction with the trip	-0.02	0.04	0.52	
	Male (Ref: Female and other)	0.00	0.08	0.95	
	No cars (Ref: Car owner)	0.20	0.08	0.00	***
	Education - Primary school (Ref: 2+ year higher ed.)	-0.04	0.22	0.17	
	Education - Highschool (Ref: 2+ year higher ed.)	0.08	0.19	0.02	*
	Education - Vocational (Ref: 2+ year higher ed.)	0.03	0.11	0.28	
	Education - Shrt higher education (Ref: 2+ year higher ed.)	0.02	0.15	0.49	
	Age - 18-29 (Ref: 70+)	0.01	0.25	0.77	
	Age - 30-39 (Ref: 70+)	0.09	0.19	0.00	**
	Age - 40-49 (Ref: 70+)	0.11	0.14	0.00	***
	Age - 50-59 (Ref: 70+)	0.21	0.11	0.00	***
	Age - 60-69 (Ref: 70+)	0.12	0.10	0.00	***

***: p <=0.001, **: 0.001<p <=0.01, *: 0.01<p <=0.05 , . : 0.05 <p <= 0.1

Discussion

This study found a high correlation between attributes measured at and around the stations. The experience on the way to a station might have a lasting influence on the experience at the station and vice versa, resulting in similar measurements. This should encourage planners to have a more holistic approach when designing stations and urban environments. Respondents might also have had difficulty differentiating between stations and their surroundings. However, as we explicitly mentioned the difference in each question, we believe this to be less likely.

The perceived safety analyses confirm gender effects in line with the literature. Among the hypothesised attributes, the presence of isolated areas and lighting were significant as expected while it is interesting that maintenance, for example, does not influence perceived safety.

It is initially unexpected that trip satisfaction does not significantly affect the frequency of PT use as, for example, Ingvardson & Nielsen (2019) found a positive significant relationship. One key difference between the two studies is that our sample consists heavily of captive PT users who never drive. Therefore, they might have to use PT even though they are dissatisfied as van Lierop, Badami & El-Geneidy also highlight in their review (2018). Susilo & Cats (2014) also state that choice users are often more satisfied than captive users.

As our structural model shows, home and activity ends have many significant parameters in common, although more factors are significant at the former. That said, many of the attributes at both ends, such as perceived safety, were correlated and this might have influenced model findings. One reason for this correlation can be the representation of the same stations with high passenger volumes in both ends. Another reason can be respondents' strong personal preferences. This will be considered explicitly in future work.

While the SEM results provide interesting insights, the model can and will be further developed. First, the SEM model lacks some important predictors of PT use such as service headway and trip duration in comparison to other alternatives. We will include such variables to get a clearer outcome and potentially improve model fit.

Second, the results are based on a relatively large sample of PT users, acting as a valuable source to understand actual users' needs and preferences. However, the age bias in the sample might have had an effect on the findings as younger individuals' preferences were under-represented. In March 2023, we will send the survey to a subset of respondents from the Danish NTS between 2018-2022 to achieve a larger and more representative sample. This way, we can also include more attributes such as bicycle parking which were left out due to having too many missing values. By including less frequent PT users in the data set, we can also test whether the relationship between satisfaction and ridership holds among different, and more representative, user groups.

5 Conclusions

This study analyzed the influence of station characteristics, urban surroundings and perceived safety on satisfaction as well as PT ridership, in East Denmark. Using 1,004 observations from our tailor-made survey, we employed a SEM model and first, we created latent variables from environment attributes which are highly correlated at and around stations as well as perceived safety and satisfaction variables. Second, we showed a significant relationship between (i) perceived safety and satisfaction with trip-ends, and (ii) satisfaction with trip-ends and overall trip satisfaction. While doing so, we identified which BE attributes should be present at stations and surroundings. Lastly, we could not demonstrate a significant effect of trip satisfaction on frequency of PT use. However, we expect that to be due to our sample's high share of captive PT users. As part of our future work, we will collect more data to achieve a more representative sample and incorporate more trip-related attributes to our SEM model to further investigate the relationship between the satisfaction constructs and PT ridership.

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