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Do accessibility, vulnerability, opportunity, and travel characteristics have uniform impacts on the traveler's experience?

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1. Introduction

For medium and long distance trips, Public Transport (PT) widely remains the most relevant alternative of mobility to motorized private vehicles, especially in urban environments. PT aims to fulfill the mobility needs of all type of travelers but particularly of those who, for instance, cannot afford to buy a private vehicle, are too young or too old to drive, have any impeding disability to drive and/or who by principles (e.g. environmental conscious) make the decision to live without a motorized vehicle.

All PT travelers are, regardless of the complexity of their door-to-door trip, exposed to the characteristics of the design and the quality of infrastructure of the vehicle, stations, stops, and interchanges, either when traveling, boarding, alighting, or transferring. During door-to-door trips, a significant part of the out-of-vehicle time takes place in the above mentioned PT premises (stops, stations, and interchanges) and includes walking, waiting, and transferring times. Iseki et al. (2006) found that the time experienced outside the vehicle is negatively regarded by travelers. Moreover, PT premises are the primary interface for travelers with PT services, and a place where travelers spend a significant and relevant part of their trip. For example, Uppland's public transport authority (UL, 2013) reported that between a 10 and a 30% of the waiting time is spent in bus stations. Time spent in PT premises should therefore be studied in more detail. In addition, travelers may experience PT premises very differently depending on their personal and trip characteristics; which include their vulnerability, captivity, and attitudes towards existing travel alternatives.

There is a large body of literature that studies traveler's satisfaction evaluations with the quality of the PT services from a main mode perspective, disregarding the influence of access and egress stages on travel satisfaction (Stradling et al., 2007; Nathanail, 2008). In addition, various approaches have been used to examine the importance attached to a very varied number of service attributes for different traveler groups (Dell'Olio et al., 2011; Cantwell et al., 2009), specific travel modes (Susilo and Cats, 2014; Mouwen, 2015), on different urban contexts (Diana, 2012) and sites (Friman and Fellesson, 2009).

However, only a handful of studies have specifically examined the impact of characteristics related to PT premises and infrastructure on travel satisfaction (e.g. Hernández et al., 2014). Furthermore, in these previous studies, the design and infrastructure characteristics have been examined from the perspective of an average traveler and focusing on specific design and infrastructure attributes that matter in stations/stops and interchanges. Moreover, in evaluating the impacts of such transport infrastructure, it is commonly assumed that their influences are uniform across different groups of travelers. This would leave some users more disadvantaged than others. However, this study hypothesizes that different market segments have different needs and appreciations towards different support and infrastructure characteristics. Thus, there is a need to identify different market segments across PT users. At the same time, whether PT premises' characteristics impact differently for distinct profile of travelers and the degree to which they do remain an open question. It also remains unknown the magnitude to which design and infrastructure of PT premises impact on door-to-door travel satisfaction and on the access, main, and egress trip segments.

The lack of knowledge on the influence of design and infrastructure of PT premises on overall travel satisfaction across different traveler groups may lead us in putting too much emphasis on more costly service aspects which may cause either too expensive and/

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or unnecessary investments in those areas. The results of this study will therefore be of special interest for PT authorities and operators together so they can better quantify and evaluate the importance of design and infrastructure for different users groups. The results will also help them to provide an equitable use of PT infrastructure and make more efficient investments to increase the attractiveness of PT.

This study contributes to the knowledge by exploring the impact of a novel combination of characteristics of the travel and the traveler which are believed to impact on the perception of the quality and design of PT infrastructure. These characteristics represent the individual's habit, captivity towards multimodality and include opportunity, vulnerability, travel attitudes and travel characteristics. Based on traveler segments, this study examines both the effect of quality of infrastructure and the design of PT premises on the overall travel experience and on the individual trip stages. More specifically the questions to be answered are: (a) what is the impact of transport infrastructure, design and inter-modality on the overall trip, and on each of the trip segments?, (b) do different types of travelers perceive the quality of transport infrastructure and inter-modality characteristics differently?

The following section provides a literature review on travelers' experience, service quality aspects that have been found to be more relevant, and, on previous segmenting works, including their results and segmenting variables. We then describe the survey, data issues and the dataset employed in the analysis. Next, we discuss how Stockholm's travelers are segmented based on Latent Class Cluster Model (LCCM) and characterize the traveler segments. This is followed by Ordinary Logit Model (OLM) estimations that will reveal the preferences, design and infrastructure wise, of the previously yielded traveler segments. The paper is closed by a discussion and conclusion section.

2. Literature review

2.1. Door-to-door trips

Unlike private car trips, the whole PT travel experience is more complex and multimodal in nature, entailing different travel modes and waiting, walking, and transfer times. A door-to-door PT trip consists of a main leg which is usually the longest leg in duration and trip legs that come before and after the main. These legs are referred as access (before) and egress (after) trips stages and sometimes are regarded as the vulnerable part of the trip due to the use of slow modes and their exposure to the built and external environmental conditions of the given place (Krygsman et al., 2004).

Travel satisfaction with door-to-door trips is commonly measured through overall travel satisfaction which can be interpreted as a measure of how travelers evaluate the entire package of service attributes (Hensher et al., 2003). In an analogous way, trip leg satisfaction would encapsulate a weighted assessment of trip leg related service attributes.

2.2. Traveler experience

A large body of literature has studied the link between travel experience and traveler satisfaction. Literature has addressed the impact of a wide variety of travel aspects on overall travel satisfaction and on how they influence the evaluation of PT service attributes. These travel aspects have included socio-demographic characteristics (e.g. Dell'Olio et al., 2011), travel characteristics (e.g. Susilo and Cats, 2014), built environment characteristics (e.g. Cao and Ettema, 2014), data collection methods (e.g. Susilo et al., 2017), disruptions (e.g. Ettema et al., 2016), the impact of tendering (e.g. Mouwen and Rietveld, 2013), weather characteristics (Ettema et al., 2017), subjective well-being (Bergstad et al., 2011) and accessibility measures (e.g. Woldeamanuel and Cygansky, 2011).

The above empirical research has yielded a wealth of results that not always agree with each other. In general, previous studies concur that travel time exerts a negative influence on travel satisfaction, for both commuters (Cantwell et al., 2009) and non-commuters (Olsson et al., 2013) regardless of the travel mode (St-Louis et al., 2014). There is a general agreement that high travel satisfaction levels are found amongst travelers using soft modes (walking and cycling). Nevertheless, there is no clear evidence on how the use of the remaining travel modes (PT modes and car) impact on travel satisfaction. For example, while St-Louis et al. (2014) showed that after walk and bike train commuters were amongst the most satisfied, Ye and Titheridge (2017) showed the opposite. The same contrast applies amongst PT modes. Some authors (e.g. Mouwen, 2015) found that metro and train users report lower levels of satisfaction with their trip compared to bus users, while others (e.g. Cao et al., 2016) proved that metro travelers report the highest satisfaction compared to BRT and bus users. Familiarity with the travel service has also yielded different results. For instance, Woldeamanuel and Cygansky (2011) found that travelers with a seasonal PT card, and therefore it is assumed frequent travelers, are found to be more satisfied than their counterparts. In contrast, Van't Hart (2012) demonstrated that frequent users are more exposed to negative critical incidents and thus their travel satisfaction is lower. In any case, previous research shows that most of these travel aspects have an effect on the travel experience and thus need to be included in the analysis.

In recent years, the determinants of travel satisfaction for the main mode have been largely studied. Employing a different composition of METPEX dataset, Ettema et al. (2016) found that station design is relevant in the main leg. In turn, when considering a full set of PT service attributes, frequency, reliability and duration are usually considered the most important service attributes (e.g. Iseki et al., 2007; Mouwen, 2015). Tyrinopoulos and Antoniou (2008) added to frequency, network coverage and three attributes related to the characteristics of the infrastructure such as vehicle cleanliness, waiting conditions and transfer distance. Furthermore, Dell'Olio et al. (2011) incorporated to the list comfort and cleanliness for current and potential PT users.

2.3. PT infrastructure

Compared to PT stops and stations, interchanges are spaces that involve not only users but also commonly involve different transport modes, services and more complex facilities (Hernández and Monzón, 2016). However, the quality of the PT system is also determined by other aspects such as the connections between different travel modes and thus of the transfer experience (Guo and Wilson, 2007). Concurring with the latter, Eboli and Mazzulla's study (2012) proved that in addition to service operation attributes, vehicle and station cleanliness were important attributes in train trips. Furthermore, waiting and transferring times are a relevant part of door-to-door PT trips, representing about a 25% of the total travel time (Iseki et al., 2006), and transfers being present in up to a 50% of the trips (In Chicago: Guo, 2003). Despite generally being an integral part of the PT transport journey, interchanging transport, tend to be negatively perceived by travelers (Hine and Scott, 2000).

In fact, the perception of PT premises such as stations, vehicles, stops and transport interchanges may vary as a function of the personal and travel characteristics. Station and vehicle design have generally been regarded as an important attribute by travelers with special needs. The elderly, for example, would, require a sheltered stop and seating facilities (Shrestha et al., 2016). METPEX (2014) demonstrated that travelers with small children in prams and those with a mobility impairment experience issues while traveling. The first group complained that they had to compete for the limited space dedicated to prams and wheelchairs with disabled and mobility restricted travelers. Mobility impaired also complained with finding non-functioning elevators and escalators at the stations. Another issues related to vehicle and stop design include the lack of boarding ramps and the lack of space on-board to maneuver. A distinct traveler group, teenagers, was found to value a sense of security, especially after dark (Cain et al., 2005). A more technologically driven generation, millennials (18–34 years of age in 2014) were found to prefer travel modes where they can get distracted and that can provide them with the opportunity of making a better use of their travel time by means of multi-tasking (Circella et al., 2017; Puignau et al., 2016). Similarly, for shopping and tourism related trips, it is speculated that a designated space in the vehicle would be necessary to leave bulks and packages.

The term design of stops, stations and interchanges comprises a number of key attributes that appear in several design guidelines. Security (including safety), service information (including ticketing and wayfinding) and shelter (general waiting environment including seating and cleanliness) are amongst the relevant factors for stops and stations (PTIDG, 2013). The size and inter-modality associated with transport interchanges add two additional design aspects: accessibility (including access between modes, co-ordination between operators, ease and distance) and facilities (eg. toilets, food, retail). Furthermore, Hernández and Monzón (2016) indicated some additional relevant attributes related to: emergency situations (signposting, information, location of exits), design and image (internal, external and station surrounding design) and environmental quality (air temperature, air pollution, temperature). In turn, vehicle design is transport mode dependent and embraces characteristics regarding comfort, safety, information, facilities and accessibility.

A number of scholars studied the PT premises and infrastructure aspects that matter the most for travelers. Waiting and transferring time perception is of large relevance and it has been found to diminish in stops that count with for example benches and shelter (Fan et al., 2016). Perceived safety and security, in addition to the characteristics and design of the station/stops, also influence time perception (Iseki et al., 2006). Yoh et al. (2012) when investigating a number of stops and stations in California also found that safety and reliability were the most important attributes. These two attributes were followed at a distance by amenities such as cleanliness, shelter, lighting and information only for long waits. The analysis of 5 interchange stations in different european cities (Madrid, Helsinki, London, Budapest and Thessaloniki) revealed that their main weaknesses were the difficulty to navigate inside the station, the lack of information on screens, the poor internal and external design and also the poor design of the external areas surrounding the interchange. At the same time, Iseki et al. (2007), argued that diminishing waiting times and improving reliability were significantly more important than investing in designing attractive and physically appealing stations. Moreover, while Eboli and Mazzulla (2007) found that attributes related to bus stops such as maintenance and furniture (bench, shelter) were considered as important for students, Dell'Olio (2011) found the opposite. Furthermore, Karlsson and Larsson (2010) found that availability of seats matters the most for the elderly, smell for the youth (15–24 y.o.) and storage possibilities for women. In conclusion, there is reason to assume that station design and infrastructure characteristics influence overall trip satisfaction, but this has to date not been fully investigated.

2.4. The call for segmentation

A large number of studies (e.g. Abreu and Bazrafshan, 2013; Iseki and Smart, 2012) have proved the need of traveler segmentation. Abreu and Bazrafshan (2013), found that travelerś characteristics and the operational conditions of the interchanges facilities influence travel satisfaction levels. In the same line, Iseki and Smart (2012) found that travelers' characteristics influence in generating a different perception of stops and stations attributes. For example, travelers that made their trip infrequently, found the ease to get around and access related variables more relevant than their counterparts.

By conducting marketing segmentation, several studies (Anable, 2005; Krizek and El-Geneidy, 2007; Beirao and Cabral, 2008; Shiftan et al., 2008; Jacques et al., 2013; De Oña et al., 2014; Abenoza et al., 2017; Lierop and El-Geneidy, 2017) have attempted to reduce the complexity that entails the variety of features and attributes that influence travelers' evaluation. These authors have employed different segmentation methods in conjunction with a varied mixed of segmenting variables (socio-demographic, travel characteristics, travel attitudes, level of car use, preferences or accessibility measures) to pursue distinct goals. Market segmentation is a group of techniques dealing with the large and sometimes unmanageable diversity of travelers by classifying travelers into a much smaller number of tractable segments. Jacques et al. (2013), for example, segmented travelers based on travel characteristics, trip satisfaction, familiarity, age and trip practicality (a ratio between travel time of the alternative mode and the chosen one). Furthermore, Shiftan et al. (2008), identified traveler segments based on socio-economic attributes and travel attitudes. The best attitudinal attributes defining the segments were their need to have a fix schedule, willingness to use PT and their sensitivity to time. Based on a mix of factorized attributes, Lierop and El-Geneidy (2017) developed a trans-modal segmentation of PT users. Their cluster analysis yielded a number of user groups which were further aggregated into captives, captives by choice and choice users regarding their income and their access to a vehicle. The results of their work demonstrate the existence of a group of PT users that is captive by conviction and convenience and not by force.

Captivity and travel attitudes have been seen to impact on travel satisfaction and thus employed in market segmentation. In a European-based study (Abenoza et al., 2017), PT captives were found to be more satisfied with their trip than choice riders, while this was found to be the opposite in a number of American based study (e.g. St-Louis et al., 2014). Travel attitudes and preferences towards environment, life and travel modes have also been found to be impactful. For example, travel attitudes were found to directly impact travel satisfaction and indirectly mode choice in a study on commuters in Xi'an, in China (Ye and Titheridge, 2017). The results of their study also demonstrate that having positive attitudes towards traveling positively influence overall travel satisfaction evaluations.

The segmentation technique used in the present paper, LCCM, has occasionally been employed in the transportation domain (Greene and Hensher, 2003; Teichert et al., 2008; Shen, 2009). Greene and Hensher (2003), for example, compared mixed logit model with latent class model and found that while both methods have their advantages, latent class models can better explain behavioral measures of performance. In the same line, Shen (2009) corroborated than the performance of latent class models is statistically superior to mixed logit models when comparing travel time savings, direct choice elasticities and estimated predicted choice probability. Furthermore, for air travelers, Teichert et al. (2008) proved the superiority of a post hoc segmentation process based on service attributes and by means of latent class analysis compared to an a priori segmentation based on travel class and trip purpose. Summarizing, LCCM is a method that embeds a number of general and specific (to the data) advantages which are listed at the end of Section 4.1.

3. Data

We analyze the data collected in a survey that was conducted as part of the METPEX FP7 EU project. METPEX, a Measurement Tool to determine the quality of the Passenger Experience, aimed to develop a Pan-European standardised measurement tool to measure travelers' experience across door-to-door trips. See Susilo and Abenoza (2017) and Susilo et al. (2017) for a more detailed description of METPEX project.

3.1. Survey

METPEX questionnaire was designed to address the entire door-to-door trip, different travel modes and user groups, and thus to facilitate a large number of analyses regarding the entire travel experience. METPEX survey was adapted to 5 different survey methods: (1) Paper and pencil; (2) Web-on-line; (3) Sbnavi app; (4) Game app; and (5) Focus groups. These survey methods consisted of a similar set of questions and could be filled in between 20 and 30 min. The survey was carried out simultaneously in eight European cities between September and October 2014. In the present study, however, in order to control for the diversity of transport infrastructure, urban fabric, weather, culture and quality of the public transport service delivered, we exclusively use the largest subset of data, the one from Stockholm.

The questionnaire consisted of five sections: (a) Traveler information - socio- demographic, mobility behavior and mode usage; (b) Attitudes - travel preferences and travel-related opinions; (c) Contextual variables - including trip purpose, weather conditions, subjective well-being. (d) Travel satisfaction with overall trip, individual trip legs and respective service attributes; (e) Specific user groups and travel mode questionnaires.

3.2. Variables

In order to fulfill the aim of this study and characterize the dataset, we employ the following variables collected in sections (a), (b), (c) and (d):

- **Socio-demographic;**
  Gender, age, education, income, occupation, disability, car in household, household composition and type of area of residence.
- **Travel Characteristics;** related to the current or most recent trip:
  (a) *Trip purpose:* categorized into commuting to work/school and other (shopping, leisure, tourism, medical appointment).
  (b) *Trip duration:* Regarding the entire journey. Given that the average commuting travel time in Stockholm is 41 min it was categorized into 40 or less and > 40 min.
  (c) *Trip frequency:* categorized into often (weekly or more often) and not often (monthly or less often).
  (d) *Travel modes* used in each trip-leg: including walking, bicycle, private vehicle, underground, commuter train, tram and bus;
- **Travel attitudes**: Likert scale measurement from 1 (completely disagree) to 5 (completely agree).
  (a) City fulfills travel needs: The city fulfills my travel needs.
  (b) PT safety: I always feel safe using public transport.

(c) No accessibility barriers: I do not face any accessibility barrier in the journeys I make.
(d) Avoid transfers: I am willing to travel a little longer to avoid changing transport modes.
(e) Mode switching: My transport mode choice depends on my circumstances. E.g.: trip purpose, traveling with children.

- Service and quality attributes;
  (a) *Leg-specific* and *overall satisfaction* with the trip: Likert scale measurement from 1 (very dissatisfied) to 5 (very satisfied). Service attributes:
  (a) *Integration:* The different modes of transport I used worked well together.
  (b) *Infrastructure:* The quality of transport infrastructure (e.g. whole transport service) during my journey was good.
  (c) *Station design:* Design of stations was adequate for my needs.
  (d) *Interchanges design:* Design of transport interchanges (main terminals) was efficient.
  (e) *Stops design:* Design of transport stops was adequate for my needs.
  (f) *Vehicle design:* Vehicle design was suitable for my needs.

3.3. Data treatment

In total, 993 responses were collected in Stockholm, of which 536 records were of trips containing a PT mode. Samples not including a PT mode were disregarded of the analysis. In addition, game app responses (N = 227) could not be incorporated since the travel modes were not stated. Thus, after the dataset was cleaned and verified for completeness, consistency and reliability across the different parts of the survey used, the sample size was reduced to 448 trips reported by different travelers.

A total of 154 samples are single-legged trips and 294 multi-leg trips, comprising of at least two trip legs (i.e. an access or egress and a main trip leg). The longest trip leg in duration is considered as the main. Sbnavi app did not ask respondents to specify their longest trip. Instead, the main trip leg for Sbnavi multi-leg trips (N = 37) was determined applying a general rule of thumb for which PT modes are considered as the longest. In case of a journey consisting of more than one PT mode; train, metro, tram and bus, in this order, are considered the longest. In some other cases, when possible, the longest leg was determined by using origin and destination and the help of a route planner.

Data transformations which included reclassification of variable categories, aggregation of trip legs into trip segment satisfaction and data imputation were carried out. The missing values found in some of the service attributes were input by employing an Ordered logistic regression imputation method. The imputation method had as a dependent variable the targeted service attribute and as independent overall travel satisfaction and a group of 5 other service attributes. The use of this method allowed to increment the sample size employed in the final Ordered Logit Models (OLM) from 349 to 416 samples.

PT captives are defined as travelers who cannot travel independently by motorized private modes. In this research, PT captive is a composite variable embodying travelers who meet at least one of the following criteria: being under 18 years old, living in a household with no private vehicle or having a disability that limits their driving. Travelers with visual and mobility impairments and long term sickness were considered as limiting disabilities to drive.

A different group of travelers are those whose mobility is limited or constrained and that they feel more endangered or at risk due to their physical condition or personal situation. In this study, travelers over 65 years old and those who live, at least, with one child in their household are considered as vulnerable travelers. It is assumed that those living with a child also travel with their child.

4. Results

4.1. Descriptive statistics

Table 1 presents summary statistics of the socio-demographic characteristics and mobility patterns of the entire dataset. Among the sample there is a somehow balanced gender distribution with a rather low income distribution (81% average or less) that is dominated by workers (38%), followed by students (28%) and part-time workers (19%). The trips reported are work or study related for about half of the samples, have predominantly a duration below the average for Stockholm (64%) and are made at least once a week (67%). Approximately three quarters of the sample lives in urban to very urban areas and report a trip starting in a residential or rather residential area (79%).

The average number of legs per trip is 2.39, totaling 1073 legs. In terms of travel mode composition, PT is in a 95% of the cases the main travel mode of the door-to-door trip. As expected, considering all trip legs, walking is the most employed travel mode (36%) due to their high presence in access (61%) and egress (59%) stages. Metro and bus (22%) followed at a distance by train (14%) are widely employed modes which have a much larger prevalence in the main leg.

4.2. Market segmentation

The segmenting variables employed[1] in the market segmentation are a combination of the attributes that in the literature review

[1] In addition the following variables were tested in the LCCM: One variable related to the type of built environment where the respondent lives (1–5 from very rural to very urban) was included in the LCCM but did not yield good results. Another variable related with the type of area where the trip starts (1–5 from mainly residential to mainly workplaces) but was not found meaningful in the segmenting process. It was attempted to retrieve travel times at a trip leg level by using the

Table 1
Sample profile (in %).

		Entire	Access	Main	Egress
Gender (N = 447)	Female	58.8			
Age	< 18	8.3			
	18–34	48.5			
	35–64	35.3			
	> 65	8			
Income	Under	39.5			
	Average	41.5			
	Above	19.0			
Education	Less than high school	9.4			
	High school	49.1			
	Bachelor or more	41.6			
Occupation (N = 439)	Worker	38.2			
	Student	27.7			
	Part time workers	19.2			
	Other	14.9			
Purpose	Work/study	55.1			
	Other	44.9			
Duration	< =40 min	64.3			
	> 40 min	35.7			
Frequency	Often (once a week or more)	67.6			
	Not often (once a month or less)	32.4			
Area of living (N = 422)	Rural/neutral	27.3			
	Urban/very urban	72.7			
Type area start trip (N = 441)	Residential/neutral	78.9			
	Workplaces	21.1			
Captivity	Yes	59.6			
Trip leg travel modes	Metro	22.5	9.3	36.2	16.8
	Walking	35.6	60.6	2.7	58.6
	Bus	21.3	17.7	27.9	14.9
	Train	14.4	4.1	28.3	4.5
	Car	2.2	3.8	1.8	0.7
	Other (tram and bicycle)	3.9	4.5	3.1	4.5
Car household	1 or more	47.1			
Limiting disability	Yes	9.8			
Vulnerability	Yes	27.7			
Living in household with 1 or more child	Yes	20.7			

have been seen to influence travel satisfaction and the perception of infrastructure characteristics. These variables include a mix of travel characteristics (duration, purpose, frequency), of captivity and vulnerability (see Section 3.3) and of travel attitudes (see Section 3.1, travel attitudes *a-e*). Relevant attributes of some socio-demographic variables (age, car ownership, disability and household composition) are exclusively employed in the construction of the two composite segmenting variables, vulnerability and captivity. The segmenting variables used were checked for multicollinearity issues. No interaction terms were needed due to the nature of the cluster method employed.

The method employed is a latent class cluster model (LCCM) which segments travelers into groups based on the conditional probability of scoring high for a specific response, given the class membership of the respondent. The specific responses of the segmenting variables form data response patterns which are represented by a range of classes or segments. Travelers are assigned to exclusively one segment, thus the sum of prevalences adds up to 100%. Model parameter estimation employs two iterative algorithms which are the Expectation-Maximization and the Newton-Raphson. The number of maximum iterations of each algorithm are set to 250 and 50 respectively. Iterations stops when the convergence criteria, 1×10^{-8}, is met. To prevent the possibility of both obtaining boundary and local solutions, Bayes constants are fixed to 1 and a set of tools are used to generate random starting values. More information on the specifications of this method can be found in Vermunt and Magidson (2005). The statistical software employed to obtain LCCM's segments was XLSTAT, a statistical add-in for excel which offers a reduced version of the broadly used LatentGOLD package.

The principal advantages of using the present segmentation method are: the possibility to include ordinal and nominal variables, the lack of noise (samples which are not classified in any segment), and, the non-parametric essence (non-linearity, normality and homogeneity assumption). Additionally, LCCM provides a scoring equation, which can be used to classify new samples into their most likely segment as a function of the observed variables (Vermunt and Magidson, 2005).

(*footnote continued*)
origin and destinations provided and a route planner, but were not included due to data incompleteness.

Table 2
Latent class cluster models solution (in %).

Variables	Categories	Segment 1 Content urban commuters	Segment 2 Unfulfilled rural travelers	Segment 3 Active leisure travelers	Segment 4 Vulnerable mode switchers
Cluster size		40.63	21.88	20.03	17.46
Captivity	Yes	62.86	58.88	75.86	34.25
Purpose	Work/study	97.42	48.14	14.20	12.47
	Other	2.58	51.86	85.80	87.53
Frequency	Often (once a week or more)	94.19	68.38	44.63	31.32
	Not often	5.81	31.62	55.37	68.68
Total travel time	< =40 min	58.65	68.54	64.44	71.91
	> 40 min	41.35	31.46	35.56	28.09
Vulnerability	Yes	20.40	34.57	0.37	67.31
City fulfills travel needs	Disagree/neutral	20.23	70.65	25.41	11.66
	Agree	79.77	29.35	74.59	88.34
PT safety	Disagree/neutral	29.73	97.84	49.15	6.24
	Agree	70.27	2.16	50.85	93.76
No accessibility barriers	Disagree/neutral	43.65	87.14	44.47	34.81
	Agree	56.35	12.86	55.53	65.19
Avoid transfers	Disagree/neutral	54.76	61.88	31.59	56.65
	Agree	45.24	38.12	68.41	43.35
Mode switching	Disagree/neutral	39.87	32.34	52.17	22.89
	Agree	60.13	67.66	47.83	77.11

4.2.1. LCCM solution

We tested and investigated the outcome of a fixed maximum number of 6 LCCM solutions. The strength and sign of statistical quality criteria (chi-square, log-likelihood and classification statistics), but also the size of the resulting segments and previous research were used to determine a final 4 segments solution –S4, see Table 2. In terms of chi-square statistics, the selected solution had one of the smallest likelihood-ratio goodness-of-fit value (L^2: 759.580) however their p-value did not provide an adequate fit ($p > .05$). The dissimilarity index, which indicates how much observed and estimated cells differ from each other, is one of the smallest (0.491) for S4 solution. Considering log-likelihood statistical criteria, and in particular one of most widely used information criteria, Bayesian information criterion (BIC), S4 obtains one of the lowest values (5929.310). BIC considers the parsimony of the model when yielding the model fit. Moving into classification statistical criteria both; classification error and approximate weight of evidence (AWE), a model fit classification measure, similar to BIC, which in addition considers classification performance yield some of the smallest values amongst all segments (0.166 and 6713.425 respectively). Pseudo R-square statistics (standard R2 and entropy R2) values of the selected solution are amongst the highest (0.656 and 0.667 respectively). The selected solution obtains the highest entropy value (196.305) signifying that the classification is certain. In conclusion, solutions of 3 and 5 segments obtain the best results in some statistical criteria but they ranked very low in some other. All in all, the results of the statistical criteria show that the four segments solution rarely yields the best results. In turn, it generally offers the the best second results, thus offering the best compromise statistical solution.

In addition, in the chosen 4 segments solution, all segments have a significant size, being the largest one (S1) 2.41 times the size of the smallest (S4). Furthermore, a discriminant analysis, supported and validated the group membership of the 4 LCCM segmenting solution when classified 94.4% of the cases correctly. Moreover, the selected 4 segment solution also fulfilled the following Tonks' selection criteria (2009): being substantial (large and practical enough), accessible (characterized by observable variables), actionable (policies can be attracted and serve them), managerially meaningful, familiar (comprehensible composition) and compact (internally homogenous and externally heterogeneous).

4.2.2. Characterization of segments

Table 3 displays a cross tabulation between the LCCM segments and socio-demographic and travel characteristics which are used as evaluation variables.

The results of various chi-square tests of independence show that with the exception of gender and cluster membership all other associations are significant and thus not independent. The information shown in Tables 2 and 3 characterizes each of the segments with both segmenting and evaluation variables and are summarized as follows:

1. *Content urban commuters (40.6% of travelers):* Commuters living in a very urban environment who make the reported trip very often. Their trips are the longest in duration amongst all groups, being over 40 min in a 42% of the cases. It is also a group that, in general, feels that the city fulfills their travel needs and that traveling by PT is safe.
2. *Unfulfilled rural travelers (21.9%):* Female travelers (69%) living in rather rural environments (48%) who make their trips with varying purposes. They have the highest negative perceptions on: the city not fulfilling with their travel needs (71%), experiencing accessibility problems when traveling (87%) and feeling that traveling by PT is unsafe (98%). A large share of them (62%) prefers transferring over walking longer which may indicate that they feel unsafer outside than inside PT premises.

Table 3
Characterization of segments (in %).

		Segment 1 Content urban commuters	Segment 2 Unfulfilled rural travelers	Segment 3 Active leisure travelers	Segment 4 Vulnerable mode switchers
Gender (N = 447)	Male	43.3	31.2	46	42.9
	Female	56.7	68.8	54	57.1
Age	< 18	7.2	10.4	11.4	4.3
	18–34	49.4	47.9	54.5	38.5
	35–64	36.1	33.4	26.1	47.2
	> 65	7.3	8.3	8	10
Income	Under	41.8	28.1	62.5	20.0
	Average	40.7	53.1	22.7	51.4
	Above	17.5	18.8	14.8	28.6
Education	Less than high school	7.1	15.6	7.1	10.0
	High school	54.0	40.6	58.3	35.7
	Bachelor or more	38.9	43.8	34.5	54.3
Area of living (N = 422)	Rural/neutral	18.5	47.8	27.2	23.1
	Urban/very urban	81.5	52.2	72.8	76.9
Type area start trip (N = 441)	Residential/neutral	78.3	77.7	84.1	75.7
	Workplaces	21.7	22.3	15.9	24.3
Travel mode main leg[a]	Metro	39.2	29.2	39.8	32.9
	Bus	30.4	29.2	19.3	30
	Train	25.8	33.3	33	22.9
	Walking	1	2.1	3.4	7.1
Travel mode any Leg (responses[a]/cases)	Metro	22.4/52.1	21.9/53.1	24.5/61.4	20.1/48.6
	Bus	20/46.4	24.9/60.4	19.5/48.9	24.9/60
	Train	14.6/34	14.6/35.4	14.5/36.4	12.4/30
	Walking	39.7/92.3	30.5/74	33.2/83	34.9/84.3

[a] The figures do not add up to 100% because three of the travel modes are not shown (car, tram and bike).

3. *Active leisure travelers (20%):* It is the youngest traveler group, with a 66% of them below 34 years old, and the one with the lowest income, with a 63% of them under the average. They have the largest amount of captive travelers (76%) and with virtually no vulnerable travelers. Their reported trip has a purpose different than studying/working (86%) and is carried out rather infrequently. More than two thirds of them prefer walking longer to avoid transfers and probably due to their captivity are less flexible to change their travel mode.
4. *Vulnerable mode switchers (17.5%):* A 67% of them are vulnerable travelers since they either live with one or more children in their household or are over 65 years of age. Most of them (77%) state that they change their travel mode depending on the circumstances and purpose of the trip, and thus are mode switchers. Around two thirds of them are non-captive and vulnerable travelers. They are the group with the largest proportion of trips with a purpose other than work/study (88%) and of short trips (72%) made rarely (69%). It is the oldest, wealthier and more highly educated group of travelers. They believe that: the city fulfills their travel needs, that traveling with PT is safe and that their accessibility levels are relatively good (65.2%).

4.2.2.1. Traveler segments' satisfaction evaluations. Table 4 depicts average satisfaction values with the general trip, trip stages and service attributes across traveler segments. When access and egress trip stages consist of more than one leg their satisfaction is defined by a simple average of the trip leg satisfaction. An ANOVA shows that there are statistically significant (90% confidence interval) differences in the mean evaluations across satisfaction and service attributes variables of different traveler segments.

Trip stage satisfaction evaluations are higher than those made for the overall trip. This may indicate that travelers aggregation

Table 4
Means of satisfaction evaluations with trip, trip stages and service attributes.

	General traveler	Segment 1 Content urban commuters	Segment 2 Unfulfilled rural travelers	Segment 3 Active leisure travelers	Segment 4 Vulnerable mode switchers
Overall Sat.	3.71	3.81	3.26	3.69	4.09
Access Sat.	4.11	4.14	3.88	4.07	4.36
Main Sat.	3.83	3.91	3.48	3.75	4.19
Egress Sat.	3.96	3.97	3.89	3.83	4.20
Integration	3.74	3.90	3.11	3.79	4.11
Infrastructure	3.77	3.91	3.30	3.76	4.06
Station design	3.73	3.90	3.11	3.79	4.06
Interchanges design	3.60	3.75	3.00	3.61	4.00
Stops design	3.71	3.91	3.07	3.70	4.04
Vehicle design	3.86	3.95	3.41	3.87	4.21

process of individual experiences into an overall travel experience might be influenced by other factors external to the trip such as mass-media or previous travel experiences. In turn, travelers report significantly higher satisfaction with access and egress legs than with the main one. Across the board, S1 but most notably S4 travelers are the most satisfied segments. The higher satisfaction of S4 travelers (Vulnerable mode switchers) might be explained by their lower levels of captivity which allow them to choose the best travel option. Contrary to previous findings (Diana, 2012; Abenoza et al., 2017), travelers living in more rural environments (S2- Unfulfilled rural travelers) have lower evaluations of their door-to-door travel experience than those living in more urban environments (S4- Vulnerable mode switchers). The dissatisfaction of S2 travelers might be related to the lower personal safety perceptions experienced by female travelers (eg. Abenoza et al., 2018b), which might be exacerbated by the fewer amount of passers-by and traffic found in the peri-urban areas. In relation to this, there exists a strong connection between safety perceptions and overall travel satisfaction (eg. Abenoza et al., 2017). This argument is somehow substantiated by the largest amount of S2 travelers (62%) that prefer transferring than walking longer in their neighborhood. Finally, peri-urban areas are characterized by offering a lower quality of PT service, in terms of frequency and proximity to the service, which adds to the dissatisfaction of this group. For a general traveler, PT service attributes receive evaluations (3.6–3.86) that are close to the equivalent of being rather satisfied (4), in a 1–5 likert scale. However, the evaluations vary between traveler segments, being highest again for S4 travelers (4.09) and lowest for S2 travelers (3.26). Some of S2 service attributes, design of interchanges (3.00) and design of stops (3.07), obtain very low evaluations which almost trespass the satisfaction and dissatisfaction threshold of 3 points.

4.3. Service satisfaction models

LCCM yields four traveler segments with distinctive satisfaction evaluations on the overall travel experience and on each of the trip stages. This might be explained by the different needs and evaluations that influence the perceptions that travelers may have on different PT service attributes. A regression analysis approach is adopted to understand and measure the impact of PT infrastructure and design characteristics on satisfaction with different trip stages and the overall travel experience, and for different traveler segments.

In order to fulfill with the above objective and to explain the impact of the different trip stages on satisfaction with the overall travel experience a number of Ordinal Logit regression Models (OLM) are specified (M1 to M5). OLM is deemed to be the most adequate technique to handle the ordinal nature (from 1 to very dissatisfied to 5-very satisfied) of the models' dependent variables assuming that the incremental change between the categories of the service attributes are linear and the same.

In general, order logit model can be expressed as:

$$y_k^* = X_k\beta + \varepsilon_k \tag{1}$$

where y_k^* is the latent dependent variable of individual k. X_k is the explanatory variable set of individual k, which consists of the service attributes' values and the respective dummy variables for the travel modes associated to an individual's trip. Note that the intercept is dropped for identification issues. β is the corresponding parameter to be estimated. ε_k is the error term which is assumed as an identically distributed logistic error-term. The latent dependent variable is then associated with the observed dependent variable, y_k (5 likert scale overall satisfaction), with m = 1.5, defined as follows:

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

The model specification comprises 5 different models. Model 1 – M1- studies the weight that trip stages have on generating an overall travel satisfaction evaluation. Models 2–5 -M2-M5- investigate the impact of 6 service attributes related to the design and infrastructure of PT. The studied impact of M2-M5 models is either on: overall travel satisfaction (M2), access satisfaction (M3), main mode satisfaction (M4) or on egress satisfaction (M5). Models 2–5 control for the impact of travel modes used by including dummy variables of the modes employed in any leg of the entire trip (M2) or in each of the trip stages' legs (M3 to M5). Table 5 displays the model specification identifying the dependent variables as "Dep." and the independent variables (service attributes and travel mode dummy variables) as "Ind." . Models 1–5 are estimated for all travelers together "General model" and for each of the four traveler segments. The independent variables were tested for multicollinearity issues with no positive results. M1 exclusively includes samples containing each of the trip stages while M3 and M5 trips include samples containing main and at least the access or egress legs, respectively. In turn, Models 2 and 4 include all samples.

Table 6 shows the results of the estimated coefficients of the trip stage satisfaction models (M1). These models are statistically significant at a 95% confidence interval. The goodness of fit of the models, represented by the widely employed Nagelkerke pseudo R square index, shows high values for the general and S1 sub-models 0.460, explaining a 46% of the variation in overall satisfaction.

All the independent variables of the general and S1 sub-models are significant at a 95% while only satisfaction with the main mode is significant for sub-model S3. The insignificance of the independent variables of S2 and S4 sub-models being probably due to their small sample size. In general, the impact of the main leg is higher than that of the remaining trip stages. This difference is notable in the case of the general model and almost negligible for content urban commuters (S1), indicating that for travelers of this segment all trip stages contribute similarly in generating an overall evaluation of the trip.

Table 7 shows the results of the estimated coefficients of the overall travel service satisfaction models (M2). Across all sub-models,

Table 5
Model specifications.

	M1 General traveler	M2 Content urban commuters	M3 Unfulfilled rural travelers	M4 Active leisure travelers	M5 Vulnerable mode switchers
Overall travel Sat.	Dep.	Dep.			
Access Sat.	Ind.		Dep.		
Main Sat.	Ind.			Dep.	
Egress Sat.	Ind.				Dep.
Integration		Ind.	Ind.	Ind.	Ind.
Infrastructure		Ind.	Ind.	Ind.	Ind.
Station design		Ind.	Ind.	Ind.	Ind.
Interchanges design		Ind.	Ind.	Ind.	Ind.
Stops design		Ind.	Ind.	Ind.	Ind.
Vehicle design		Ind.	Ind.	Ind.	Ind.
Walking		Ind.	Ind.	Ind.	Ind.
PT train		Ind.	Ind.	Ind.	Ind.
PT metro		Ind.			
PT bus		Ind.	Ind.	Ind.	Ind.
PT tram		Ind.			
Car		Ind.			

Table 6
M1 – trip stage satisfaction models.

	General		**Segment 1 (S1)** Content urban commuters		**Segment 2 (S2)** Unfulfilled rural travelers		**Segment 3 (S3)** Active leisure travelers		**Segment 4 (S4)** Vulnerable mode switchers	
	Coeff.	sig.	Coeff.	sig.	Coeff.	sig.	Coeff.	sig.	Coeff.	sig.
Access Sat.	**.684****	.002	**.831***	.019	**.876**	.150	**.207**	.613	**1.419**	.365
Main Sat.	**1.061****	.000	**.832****	.002	**1.234**	.076	**1.123***	.012	**12.019**	.340
Egress Sat.	**.522***	.015	**.743***	.018	**−.452**	.621	**.408**	.355	**.588**	.561
−2 Log Likelihood	147.29		73.34		39.50		51.47		.00	
Df	3		3		3		3		3	
Pearson Chi-sq	121.97		51.33		35.66		48.02		.84	
R2 Nagelkerke	.451		.462		.351		.287		.932	
N	152		69		25		35		23	

* Significant at a 95% confidence interval.
** Significant at a 99% confidence interval.

Table 7
M2 – overall travel service satisfaction models.

	General		Segment 1 Content urban commuters		Segment 2 Unfulfilled rural travelers		Segment 3 Active leisure travelers		Segment 4 Vulnerable mode switchers	
	Coeff.	sig.	Coeff.	sig.	Coeff.	sig.	Coeff.	sig.	Coeff.	sig.
Integration	**.555****	.000	**.465***	.012	**1.127****	.000	**.676***	.042	**-.508**	.360
Infrastructure	**.798****	.000	**1.212****	.000	**.048**	.870	**1.576****	.000	**.800**	.129
Station design	**.047**	.736	**−.358**	.101	**.619**	.108	**.178**	.560	**.108**	.821
Interchanges design	**.015**	.914	**−.023**	.917	**−.459**	.125	**−.332**	.304	**1.212***	.031
Stops design	**.083**	.568	**.033**	.895	**−.407**	.182	**.102**	.760	**1.109***	.033
Vehicle design	**.387****	.002	**.509****	.006	**.519**	.057	**−.003**	.991	**.267**	.624
Car	**−.155**	.730	**−1.838***	.045	**−.643**	.386	**3.150****	.007	**.749**	.623
Walking	**.060**	.756	**.239**	.430	**.115**	.801	**.030**	.949	**−.191**	.787
PT train	**−.036**	.876	**−.301**	.409	**.038**	.940	**1.004**	.085	**−.663**	.404
PT bus	**.306**	.157	**−.263**	.431	**.483**	.364	**.078**	.887	**.852**	.224
PT tram	**−.532**	.232	**−.740**	.340	**−.437**	.599	**−.755**	.479	**−2.785**	.098
PT metro	**−.057**	.800	**−.417**	.247	**−.037**	.938	**.357**	.568	**.173**	.799
−2 log likelihood	868.93		380.39		205.51		152.98		80.00	
Df	12		12		12		12		12	
Pearson Chi-sq	1818.86		750.71		378.22		236.16		95.64	
R2 Nagelkerke	.372		.371		.348		.487		.565	
N	416		186		87		81		62	

* Significant at a 95% confidence interval.
** Significant at a 99% confidence interval.

Table 8
M3 – access service satisfaction models.

	General		Segment 1 Content urban commuters		Segment 2 Unfulfilled rural travelers		Segment 3 Active leisure travelers		Segment 4 Vulnerable mode switchers	
	Coeff.	sig.	Coeff.	sig.	Coeff.	sig.	Coeff.	sig.	Coeff.	sig.
Integration	.398*	.028	.637*	.025	−.140	.741	.592	.157	.449	.526
Infrastructure	.527	.008	.408	.231	−.018	.970	.358	.420	.963	.090
Station design	.370	.096	1.193	.004	.351	.647	−.306	.433	.699	.381
Interchanges design	.204	.315	−.465	.218	.622	.241	.744	.059	.211	.775
Stops design	−.214	.310	−.092	.798	−1.270*	.041	−.215	.587	1.077	.135
Vehicle design	−.129	.510	−.515	.108	1.118	.058	.451	.276	−1.208	.095
Walking	−.020	.951	.317	.614	2.358	.008	−.763	.273	−.790	.476
PT bus	−.226	.465	.421	.444	−.353	.659	−1.173	.128	−.939	.315
PT rail (metro + train)	−.677*	.047	−.633	.301	−.467	.535	−.458	.580	−2.362*	.021
−2 log likelihood	471.39		180.91		87.49		105.53		49.95	
Df	9		9		9		9		9	
Pearson Chi-sq	822.46		380.87		164.87		216.66		84.08	
R2 Nagelkerke	.231		.304		.370		.380		.590	
N	220		91		41		52		36	

** Significant at a 99% confidence interval.
* Significant at a 95% confidence interval.

a reduced number of 11 service attributes are significant at a 95% confidence interval. In general, service attributes related to integration, vehicle design and infrastructure are the most relevant across all but S4 sub-models. As expected, the provision of a satisfying infrastructure that embraces the entire travel experience (infrastructure) has the largest impact on overall travel satisfaction. In turn, for S4 travelers providing an efficient design of interchanges and an adequate design of stops is what matters the most. Furthermore, vehicle design impacts on the overall trip evaluation, for content urban commuters (S1) and general travelers. A reasonable explanation for this is that the trips taken by travelers of these segments are the longest, making comfortability and other vehicle design characteristics more valued. Traveling by car has a negative impact on the travel experience for S1 travelers and positive for S3 travelers. This difference in travelers' appreciations could be accounted for the nature of their trip, commuting for the former and leisure for the latter. All sub-models are significant at a 99% confidence interval and have a Nagelkerke R square hoovering between .350 (S2) and .565 (S4).

Travel mode dummies in models 3–5 vary with regard to M2 model. In M3-5 models, metro and train travel modes are aggregated into PT rail while car and tram are not estimated since they are not present in all combinations of models and sub-models.

The results of satisfaction with the models regarding the access stage (M3) are presented in Table 8. All sub-models are significant at a 95% confidence interval and have a Nagelkerke R-square moving from .231 (General) to .590 (S4). Integration and infrastructure for general and S1 travelers have a significant positive effect. However, the larger positive effect for S1 travelers is caused by station design. Contrary to what it was expected, stops design for S2 (Unfulfilled rural travelers) exerts a strong negative impact on the overall travel experience. Going by walk in the first-mile of the trip (S2) positively impacts on overall travel satisfaction. However,

Table 9
M4 – main service satisfaction models.

	General		Segment 1 Content urban commuters		Segment 2 Unfulfilled rural travelers		Segment 3 Active leisure travelers		Segment 4 Vulnerable mode switchers	
	Coeff.	sig.	Coeff.	sig.	Coeff.	sig.	Coeff.	sig.	Coeff.	sig.
Integration	.300*	.020	−.029	.878	.748*	.014	.871	.006	.405	.408
Infrastructure	.803	.000	.879	.000	.728*	.017	1.822	.000	.064	.894
Station design	.181	.195	.063	.766	.664	.090	−.022	.944	.108	.813
Interchanges design	.185	.171	.127	.562	−.193	.539	−.257	.398	1.710	.001
Stops design	.188	.202	.365	.143	−.072	.822	.276	.417	−.386	.465
Vehicle design	.019	.882	−.073	.691	.447	.133	−.740*	.033	.357	.451
Walking	−.890	.214	1.440	.831	2.711	.122	−3.868*	.027	−1.101	.429
PT bus	−1.054*	.027	−.993	.243	.607	.530	−3.457*	.015	−.232	.844
PT rail (metro + train)	−1.185*	.010	−.751	.363	.104	.913	−3.615	.007	−.338	.767
−2 log likelihood	806.26		388.85		167.70		138.02		95.36	
Df	9		9		9		9		9	
Pearson Chi-sq	1244.25		659.81		268.05		171.87		98.04	
R2 Nagelkerke	.330		.251		.499		.546		.441	
N	399		91		41		52		36	

** Significant at a 99% confidence interval.
* Significant at a 95% confidence interval.

Table 10
M5 – egress service satisfaction models.

	General		Segment 1 Content urban commuters		Segment 2 Unfulfilled rural travelers		Segment 3 Active leisure travelers		Segment 4 Vulnerable mode switchers	
	Coeff.	sig.	Coeff.	sig.	Coeff.	sig.	Coeff.	sig.	Coeff.	sig.
Integration	.145	.474	.338	.263	−.301	.563	−.081	.891	3.151	.065
Infrastructure	.470*	.028	.170	.598	1.076	.105	1.029*	.043	.225	.868
Station design	.247	.291	.457	.186	2.220*	.021	−.083	.882	.079	.940
Interchanges design	−.083	.710	.235	.519	−1.378	.077	.025	.953	−2.438	.184
Stops design	.057	.793	−.669	.118	.648	.213	.355	.514	−.449	.759
Vehicle design	.031	.888	.005	.988	−.703	.249	−.565	.319	4.290*	.017
Walking	.606	.056	.237	.715	.650	.377	2.028*	.014	1.349	.346
PT bus	.475	.200	−.701	.415	−.098	.900	1.985*	.046	2.287	.195
PT rail (metro + train)	−.492	.257	−1.030	.182	−.062	.961	.100	.921	−2.357	.327
−2 log likelihood	411.22		187.13		68.51		73.74		30.61	
Df	9		9		9		9		9	
Pearson Chi-sq	735.71		240.77		109.69		372.23		36.28	
R2 Nagelkerke	.160		.097		.457		.437		.719	
N	188		81		37		37		26	

** Significant at a 90% confidence interval.
* Significant at a 95% confidence interval.

the use of PT rail is negatively regarded by general and S4 travelers.

The models with satisfaction with main stage (M4) summarized in Table 9 are significant (95% confidence interval) and have a Nagelkerke R-square moving from .231 (General) to .590 (S4). For the majority of travelers, the quality of the infrastructure during the journey (infrastructure) is the attribute that impacts the most on main leg satisfaction. This is followed by the ease of inter-operability between transport modes (integration) for general, S2 and S3 travelers. In turn, the provision of an efficient design of interchanges is the only relevant attribute for S4 travelers. Inexplicably, for S3 travelers an unsuitable vehicle design generates a high satisfaction with the main mode. All significant travel mode dummies negatively impact on the evaluation of the main trip leg for general and S3 travelers.

The models with satisfaction with egress stage (M5) summarized in Table 10 are, with the exception of S1 sub-model, significant at a 95% confidence interval. Nagelkerke R-square moves from a low .160 (General) to a very high .719 (S4), this latter value being probably distorted due to the limited sample size. A very reduced number of 4 service attributes are significant at a 95% confidence interval. The quality of the infrastructure during the entire trip influences egress satisfaction for general and S3 travelers. In addition, station and vehicle design matter for S2 (unfulfilled rural travelers) and S4 travelers (vulnerable mode switchers) respectively. Walking (General and S3) and traveling by bus (S3) exerts a strong positive influence on the egress satisfaction.

4. Discussion and conclusion

Using a door-to-door travel survey (METPEX) for Stockholm and the year 2014, this study analyzed the effects of quality of infrastructure and design of PT premises on the overall travel experience. The effects were investigated for each trip stage and for different traveler segments. The segments were obtained using a latent class cluster model (LCCM) segmentation based on travel characteristics, captivity, vulnerability and travel attitudes which were either found to be impactful in previous literature or that had not been deeply explored. The LCCM segmentation process yielded 4 distinct traveler segments: i) content urban commuters, ii) unfulfilled rural travelers, iii) active leisure travelers, and, iv) vulnerable mode switchers. Practitioners can use the scoring equation output to obtain regression equations which would allow them to assign new cases to any of the traveler segments by applying probabilities.

Results from M1 (Trip stage satisfaction model) indicate that all trip legs contribute in explaining overall trip satisfaction and thus all parts of the trip are to be taken into account. The importance of all trip stages in constructing an overall travel satisfaction evaluation was also made patent in Abenoza et al. (2018a) when examining the weight that each of the trip stages has in constructing an overall travel evaluation.

The model estimation results (M2 to M5) show similarities in terms of appreciations and needs between the attributes that influence the whole trip and the different trip stages. Two attributes are found to be of outermost importance across all trip stages but especially for the whole trip and the main mode. First, the provision of well-designed travel mode integration (in space, time and money) can yield a seamless door-to-door trip (Integration). This ease to get around partly concurs with Iseki and Smart (2012) findings. And, second, offering a high and balanced quality in all kind of infrastructure involved in the entire trip experience. Therefore, practitioners would do well in improving their integrated planning, infrastructure and operations to enhance the PT integration. Moreover, the relation between satisfaction and expectation might be the reason why there is a counter-intuitive negative influence of the design of the stops (in the access stage) and of the vehicle (in the main stage).

This study also unveils particularities and important differences amongst different trip stages and traveler segments. For example, the impactful attributes for S4 travelers are not related with integration and the infrastructure of the whole journey but to an adequate design of interchanges and a suitable design of vehicles. Therefore stakeholders would do better in treating travelers differently when evaluating infrastructure and design characteristics of PT. In addition, stakeholders should put more emphasis in enhancing integration and infrastructure of the whole journey and in investigating which specific features of these two attributes are to be improved.

The use of travel modes influence overall and trip stage satisfactions differently. In general, travel modes used in access and egress stages positively impact on the satisfaction of the respective stages, while the ones used in the main stage have a negative impact. Regarding the whole trip, the negative impact of car use for S1 travelers can be related to their higher chances to be exposed to congestion in peak hours. In turn, active leisure travelers (S3) may experience car driving more pleasantly due to their more flexible schedules. Walking positively impacts satisfaction with access and egress stages (M3 and M5) while it negatively impacts satisfaction with the main leg (M4). This is partly in line with previous findings (St-Louis et al., 2014; Yang et al., 2015; Ye and Titheridge, 2017) where overall travel satisfaction is higher if walking is used in any leg. Interestingly, the results of this study suggest that traveling by a slow mode in the longest trip leg creates a disutility.

This study exclusively includes trips where PT is present and therefore it does not allow obtaining an insight onto the perception of non-PT users of design and infrastructure. The limited sample size present in certain sub-models call for caution when interpreting and transferring the results. Furthermore, a word of warning is needed when interpreting the results of a number[2] of sub-models given that some of them do not hold the assumption of proportional odds. In any case, the results of this study are encouraging and highlight the importance of taking into consideration the diversity amongst travelers when studying PT infrastructure and design characteristics in detail. This is a reason that should encourage stakeholders to collect the necessary data to perform a similar analysis employing the present methodology.

There are important issues that can be addressed by future research. The inclusion of more in detail questions regarding the specific characteristics of the infrastructure and the design of stations, stops and interchanges would be very enlightening. This would allow practitioners to disentangle the specific and tangible enhancements and improvements that matter for specific traveler groups. Alternatively, a follow-up qualitative research could shed light on additional travelers' segments design and infrastructure preferences. The interviewed travelers of this qualitative study could be assigned via scoring equation from each of the obtained traveler segments

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[2] The following number of sub-models do not hold the assumption of proportional odds: M1: 1 out of 5; M2: 2 out of 5; M3: 4 out of 5; M4: 1 out of 5 and in M5: 2 out of 4.

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